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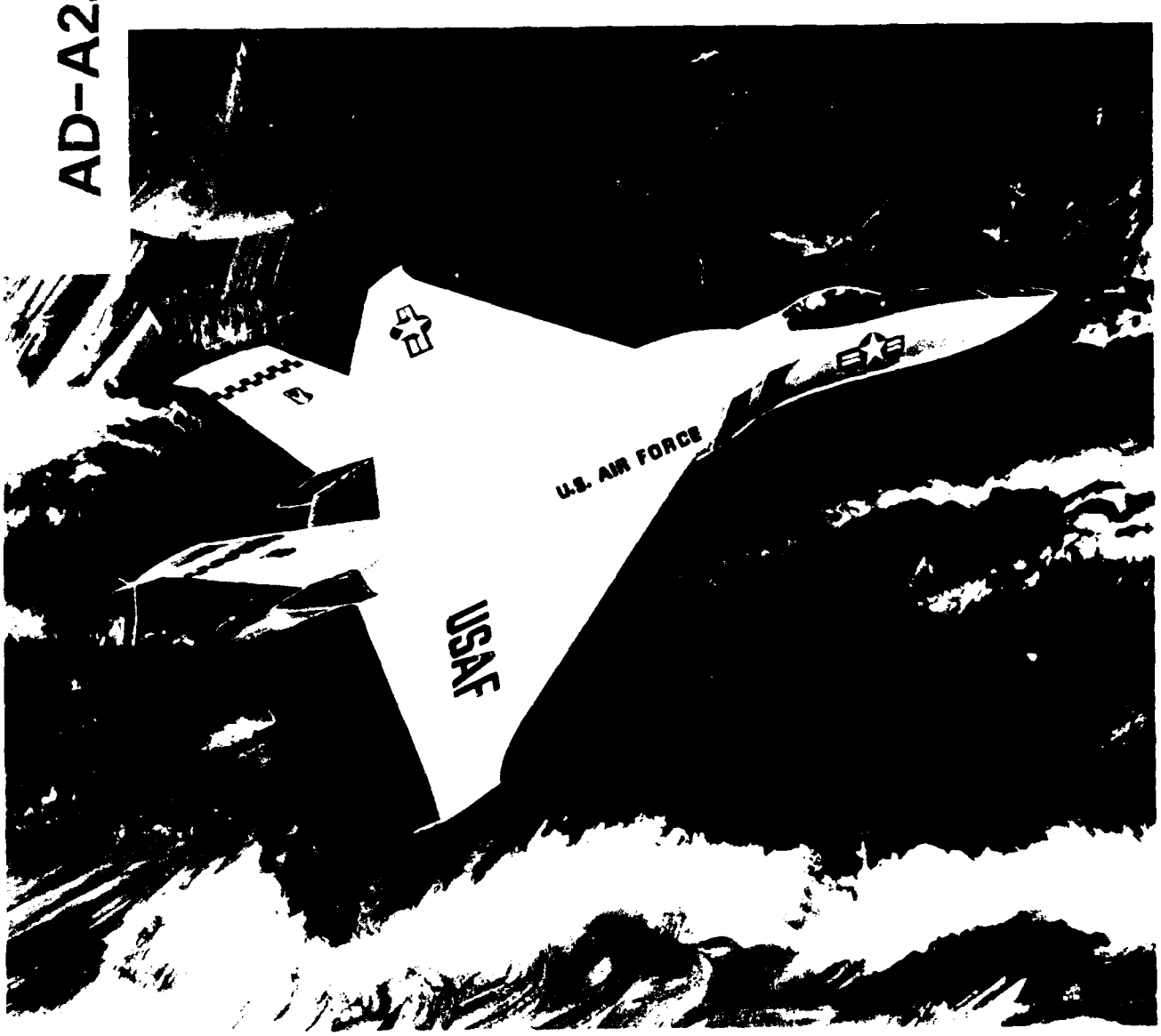
APRIL 1990

FISCAL YEAR 1990-1995 RESEARCH AND TECHNOLOGY PLAN



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This report was prepared by the Special Projects Office, HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235-5601, and this report has been reviewed by the Office of Public Affairs (PA). It is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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The plans reported here are part of a broader set of plans which are reported in the "Human Systems Technology Roadmap - 1989," published by the Human Systems Division (HSD). The Air Force Human Resources Laboratory (AFHRL), one of several HSD laboratories, is the principal Air Force Systems Command (AFSC) organization charged with planning and executing the USAF exploratory and advanced development programs in manpower and personnel, education and training, simulation and training devices, and logistics and group aspects of human factors. This document contains: (a) a description of the laboratory mission and investment strategy; (b) plans for research and development by AFHRL during the period FY 90-95; (c) a brief description of program relationships and accomplishments; (d) a list of customer requirements for research and development; and (e) general background information about AFHRL's organization, funding, manpower, and facilities.

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PREFACE

The Air Force Human Resources Laboratory (AFHRL) is part of the Human Systems Division (HSD), one of six product divisions within Air Force Systems Command (AFSC). The official plans for AFHRL are contained in the FY 90 Human Systems Division Technology Area Plan (TAP). The TAP is available only to qualified Government personnel.

This document contains detailed information about AFHRL plans at the laboratory division level. These plans are a subset of the HSD Technology Area Plan. Detailed funding information has not been included in this plan so that the plan may be made available to the widest possible audience. The plan is specifically designed for contractors and requirements managers who need detailed information about plans of specific AFHRL divisions.

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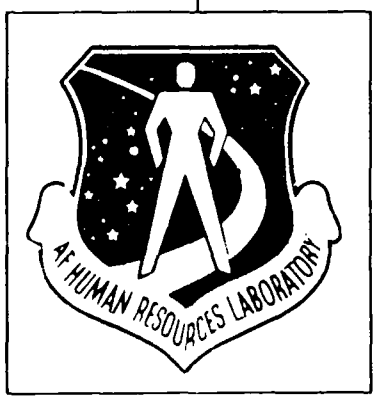

I. AFHRL CHAIN OF COMMAND

THE DEPARTMENT OF THE AIR FORCE

The mission of the Department of the Air Force is to provide an Air Force that is capable, in conjunction with the other Armed Forces, of preserving the peace and security of the United States.

AIR FORCE SYSTEMS COMMAND

Major Commands are interrelated and complementary, providing offensive, defensive, and support elements. Each support function, such as logistics, training, and research and development, is under the jurisdiction of a separate command. Air Force Systems Command (AFSC) is one such command. Under policies established by HQ USAF, AFSC's mission is to advance aerospace technology, to incorporate those advances in the development and improvement of aerospace systems, and to acquire qualitatively superior, cost-effective, and logistically supported aerospace systems and equipment. It is through AFSC that USAF's operational and support commands receive the weapons, equipment, and initial spare parts needed to defend the nation.

AIR FORCE HUMAN SYSTEMS DIVISION

The Human Systems Division (HSD) is a product division under AFSC. HSD plans, manages, and conducts research, engineering development, and acquisition programs and provides specialized operational support. Its efforts focus on the readiness, maintenance, protection and enhancement of human capabilities and human system performance of individuals, teams, crews, and force levels. It serves as a center for human systems advocacy, enabling the Air Force to meet current and future operational requirements in the four functional areas of crew-system integration, crew protection, force readiness and environmental protection.

AIR FORCE HUMAN RESOURCES LABORATORY

The Air Force Human Resources Laboratory (AFHRL), is one of four HSD Laboratories. It manages and conducts research, exploratory, and advanced development programs in manpower and personnel, flying and technical training, simulation, and logistics. The overall goal of the combined programs is to help the Air Force achieve the best methods for acquiring enlisted and officer personnel, and training and maintaining this force at peak readiness.

II. HOW TO USE THIS DOCUMENT

Unsolicited proposals to conduct research leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact. After such discussion or correspondence, you will be better prepared to write your proposal.

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective with the scientist or engineer identified with the objective. Further, you may have completely new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

As stated in AFSC Pamphlet 70-5, AFSC Guide for Unsolicited Proposals (Private industry may purchase the pamphlets for approximately $3.50 from: Command Publications Distribution Center, HQ AFSC/DAPPD, Andrews AFB DC 20334-5000), elaborate brochures or presentations are not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is important that your letter be prepared clearly so it imparts an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

1. Name and address of your organization.

2. Type of organization (profit, nonprofit).

3. Concise title and an abstract of the proposed research, and a statement indicating the submission of an unsolicited proposal.

4. Outline and discussion of the purpose of the research, the method of attack on the problem, and the nature of the expected proposal.

5. Name and research experience of the principal investigator.

6. Suggestion as to the proposed starting and completion dates.

7. Outline of the proposed budget, including information on equipment, facility, and personnel requirements.

8. Names of any other Federal agencies receiving the proposal. (This is extremely important.)

9. Brief description of your facilities, particularly those that would be used in your proposed research effort.

10. Brief outline of your previous work and experience in the field.

11. Descriptive brochures and financial statements, if these are available.

III. LABORATORY MISSION AND INVESTMENT STRATEGY

The Air Force Human Resources Laboratory (AFHRL) is the principal Air Force Systems Command (AFSC) organization charged with planning and executing the USAF exploratory and advanced development programs for research related to manpower and force management, logistics systems technology, and training technology. Manpower and force management research and development (R&D) addresses selection, classification, assignment, evaluation, and retention of Air Force members and overall force structure and utilization. Logistics systems R&D is concerned with logistics factors at each step in the development and acquisition of systems and the productivity of maintenance teams. Training technology R&D addresses the development of improved methods for training, including content, instructional strategies, delivery, evaluation, and management. Aircrew training R&D includes manned aircraft simulation, performance measurement, training technology for air combat tactics, and advanced systems to improve the quality and combat effectiveness of aircrews. Command and control (C^2) R&D includes training to improve team performance, C^2 team performance assessment, and information systems to facilitate team performance. Technical training R&D includes the use of computer-assisted methods to improve training systems, instructional and learning strategies, techniques for managing training, and techniques for evaluating job performance.

The goal of the AFHRL investment strategy is to help ensure combat success by optimizing human performance. This human-oriented approach is based on an increasing awareness that complex systems require detailed identification and training of personnel for operations, maintenance, and support.

The investment strategy at AFHRL considers:

1. The development of new technologies to meet specific weapon system needs.

2. Integration of Manpower, Personnel, and Training (MPT) technologies early in the weapon system acquisition cycle.

3. Adherence to a balance between technology development and technology application in support of customer requirements.

4. Capitalization on emerging technologies which directly impact the formulation and accomplishment of the R&D program. Examples of these technologies are artificial intelligence, miniaturized computer hardware, sophisticated software, visual display technologies, and weapon system design technologies.

5. Review of the above considerations in the larger context of support to the total Human Systems Division (HSD), AFSC, and the Air Force mission.

Investment strategy is also impacted by formal long-range planning guidance such as Air Force 2000, Air Force-endorsed Defense Science Board studies and recommendations, Air Force Logistics Long Range Planning Guide, and other requirements levied by the Air Force. Program guidance is provided periodically by both HQ AFSC and HQ HSD.

AFHRL assigns R&D priorities based on customer requirements, technical merit, and promise of technology transition to other Air Force organizations.

1. Requirement evaluations are influenced by the urgency of the proposed R&D. Mission suitability is an important part of the requirements evaluation process; i.e., the proposed work must qualify as R&D and fall within AFHRL's mission area responsibilities. Requirements are high priority if there is considerable Congressional- or general-officer-level interest in the program and the work is formally required by regulation or agreement. Even without such impetus, priority is also still high if safety, cost, or combat effectiveness would be adversely affected if the R&D were not conducted.

2. Technical Merit evaluations are influenced by the technical feasibility and timeliness of the proposed R&D, the clarity of the R&D objectives, the quality of the plans, and the potential uses of the R&D products in other efforts. Consideration is also given to AFHRL's need for research "tools."

3. Technology Transition of the R&D product to Air Force decision makers is also important. AFHRL seeks to transfer technology to those who need it,

and makes the information available to Air Force decision makers in a timely fashion.

Areas of Increasing and Decreasing Emphasis. During FY 90-95, R&D in the areas of Manpower, Personnel, and Training (MPT) integration and aircrew selection will expand. Emphasis on the Armed Services Vocational Aptitude Battery will decrease, because responsibility has been transferred to the Defense Manpower Data Center (DMDC) in Monterey, California. In the area of logistics technology, increased emphasis will be given to two 6.3 projects during FY 90-91: Simultaneous Engineering (SE) and Integrated Maintenance Information System (IMIS). The work on IMIS will then gradually decrease as the technology is transitioned to user organizations. In the area of training technology, increased emphasis will be given to multiship aircrew training and intelligent computer-assisted instruction. Decreased emphasis will be given to traditional forms of computer-based training and instructional support systems, as industry can already meet most of our needs in these areas.

Planning and Programming Cycle. Advance planning is the primary method of assuring that R&D resources are invested in technologies that meet the needs of the Air Force in a timely manner. The AFHRL Investment Strategy is implemented through a planning and programming process which is organized around the Department Of Defense (DOD) Planning, Programming, and Budgeting System (PPBS). Although new ideas are always welcome and will be considered at any time, the following activities constitute the preferred AFHRL planning cycle:

1. Thirty-three months in advance of the fiscal year in which an effort will start, division scientists prepare individual work unit proposals. Each proposal identifies and justifies the R&D being proposed, provides detail on the technical approach, and specifies the technology to be advanced, or the customer requirement to be satisfied.

2. Proposals are reviewed by the Laboratory Commander and are tentatively approved if they comply with the investment strategy criteria given above. Other reviews may be conducted by the AFHRL Technical Advisory Board or by a Research Advisory Panel of nationally recognized experts. While these reviews are ongoing, the need for front-end analysis is evaluated by the staff of the Special Projects Office. When necessary, formal front-end analyses (FEAs) of major programs are completed and incorporated into the review and approval process. Policies guiding FEAs are contained in AFHRLR 173-1, Front End Analysis (FEA) Studies.

3. After preliminary reviews are completed, AFHRL scientists develop work unit packages in compliance with AFHRLR 80-4, Laboratory Work Unit Planning, Prioritization, Approval, and Completion Procedures.

4. The final review authorizing a new start is made by the Commander before the proposed program start. Approval is based on the merit of the proposal, priority of the program, and availability of resources.

IV. BASIC RESEARCH PROGRAMS (6.1)

AFHRL conducts basic research under two Air Force Office of Scientific Research (AFOSR) tasks: (a) Manpower Management, and (b) Perceptual and Cognitive Dimensions of Pilot Behavior. This research is accomplished both in-house and by various contractors.

Learning Abilities Measurement Program

The Learning Abilities Measurement Program (LAMP) is sponsored by AFOSR Air Force Office of Scientific Research. The goals of the program are to specify basic parameters of learning ability, to develop techniques for assessing knowledge and skill levels, and to explore the feasibility of a model-based system of psychological assessment. The long-term objective is to improve personnel selection and classification systems.

LAMP is divided into two categories. The first category, Cognitive Abilities Measurement, is concerned with validating fundamental learning abilities by determining how learners differ in their abilities to think, remember, solve problems, and acquire knowledge and skills. From research already completed, LAMP scientists have established a framework that assumes that observed learner differences are due to differences in processing speed; processing capacity; the breadth, extent, and accessibility of conceptual knowledge; and procedural and strategic skills.

Air Force Recruits take the learning abilities measurement test.

The second category of research activities, Complex Learning Assessment, is concerned with new models of learning abilities. LAMP researchers have developed a number of computerized intelligent tutoring systems that serve as mini-courses in technical areas such as computer programming and electronics troubleshooting. A major goal of this part of the program is to develop principles for producing indicators of student learning progress and achievement. These indicators will serve as the learning outcome measures against which newly developed learning abilities tests will be evaluated.

In the past year, LAMP researchers have conducted a series of large-scale studies that have resulted in the development of new ability measures that are now incorporated in three experimental aptitude test batteries. LAMP scientists have also found that some of these new measures add to our ability to predict success in learning technical skills such as computer programming and troubleshooting. During FY 90 and FY 91, further studies will be conducted to determine whether the new LAMP measures can predict success in other learning situations and in operational technical training courses.

Direct payoff for LAMP research should come in the form of improved aptitude tests for enlisted and officer personnel. There may also be other benefits, such as improved systems for testing a trainee's understanding as the trainee progresses through a curriculum. A performance battery designed to assess the information processing abilities of the operator working in a hazardous or unusual environment is another possible outcome.

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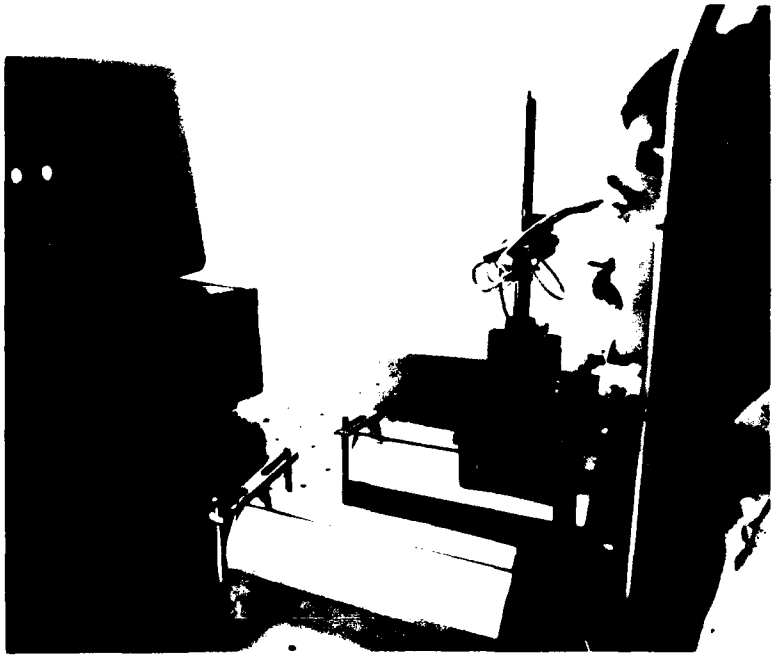
Perceptual and Cognitive Dimensions of Pilot Behavior

The pilot behavior research program deals with issues related to the cognitive and perceptual aspects of human visual information processing. Two efforts are currently underway: (a) visual attention, and (b) form processing across the retina.

The visual attention research is concerned with what aspects of the visual world will be selected for attention. One line of research deals with covert visual attention shifts (i.e., attention shifts without eye movement). The goals of this effort are: to measure the time course of attention shifts, to determine what kinds of visual information are enhanced by covert attention, to assess the effects of practice on attention-shifting speed and information processing, and to develop a model of covert attention effects. Another line of visual attention research deals with how intelligence and strategy determine each eye movement when the task is goal-driven.



Basic research at AFHRL focuses on fundamental cognitive and perceptual issues.

The goal is to understand how visual systems function peripherally.

The objective is to develop a computational model of the decision processes required for each eye movement. This research employs artificial intelligence techniques to derive rules for predicting patterns of eye movements during simplified flight instrument cross-check tasks.

The second major effort in the pilot behavior basic research program addresses the manner in which visual information is processed across the retina (including the visual periphery). Important research questions are: What aspects of a visual stimulus convey form information, and how will the underlying mechanisms operate, change, and interact at various retinal eccentricities? This research will be accomplished by using psychophysical techniques to study the perception of specified images which are created and manipulated by elementary function techniques (e.g., Fourier descriptors and two-dimensional Gabor functions). The long-range goal is to provide understanding of visual systems functions in the periphery. This information will be used to design displays that are optimally matched to human information processing abilities.

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V. TECHNOLOGY PROGRAMS (6.2 AND 6.3)

Manpower and Force Management

General Objective

This R&D develops better ways of selecting people and assigning them to Air Force specialties (AFSs); determines job and training requirements for specialties; and estimates the impacts of policy changes on the manpower and personnel process. The results will provide the basis for a variety of manpower policy decisions. Better methods are being developed for: (a) procurement and selection of quality personnel; (b) assignment of individuals to jobs compatible with their aptitudes, interests, and experience; (c) establishment of effective reenlistment and career development programs; and (d) design of improved decision aids for Manpower, Personnel, and Training (MPT) needs relative to weapon systems.

Specific Goals and Technical Approaches

1. Personnel Assessment Systems. R&D is required to develop the best possible Air Force selection and classification system. The focus is not on maintaining or replicating existing systems but rather, on developing new measures or systems that can capitalize on recent developments in cognitive, psychometric, and leadership theories.

Selection and classification continue to be a major focus of AFHRL R&D.

During FY 90-96, development of prototypes for officer and aircrew selection/classification/assessment systems will continue, along with development of prototype enlisted assessment devices which are specific to the Air Force.

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Figure 1 outlines the plans in this area. Major areas within the Personnel Assessment Systems Subthrust are:

a. Development of New Measures of Air Force Member Effectiveness and Retention Measures. New measures of attributes thought to contribute to effectiveness and retention of Air Force members are being developed. Although the primary focus is on enlisted personnel, some measures pertain to officers as well, especially in the leadership/management, commitment/values, and adaptability domains.

Future efforts will develop and refine the Leadership Effectiveness Assessment Profile (LEAP), a biographic survey designed to measure (1) potential for leadership and management; (2) the propensity to make a commitment to the Air Force as an organization; and (3) the ability to function well in team situations. Enlisted and officer prototypes will be developed, field-tested, and refined. Four sequential administrations will then be made to sample groups at Air Force bases. After field-testing, enlisted and officer versions of the LEAP suitable for operational use will be developed and validated. Performance, construct validity, and retention criteria for a large worldwide sample of Air Force members will be used in this validation process. As an additional measure of Air Force values, an Air Force Institutional Values Survey will be constructed. This will be administered longitudinally to

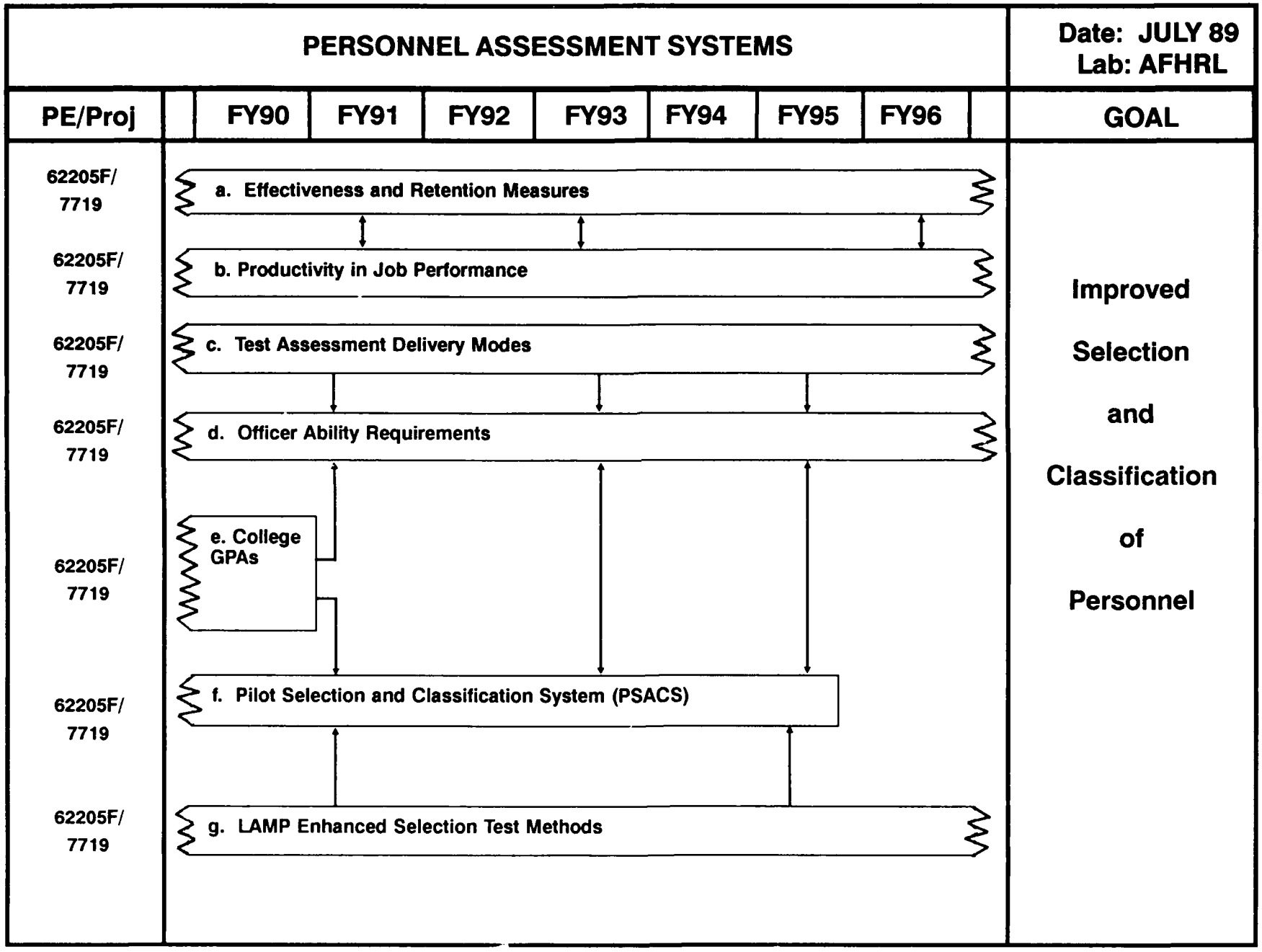
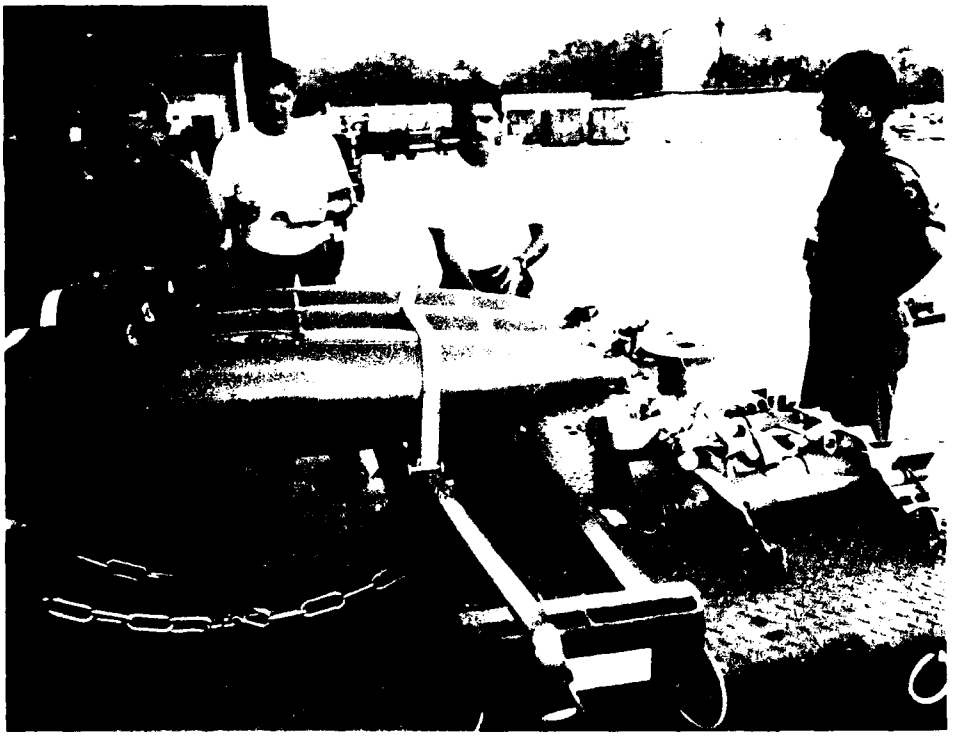


Fig 1. Manpower and Force Management Subthrust MO-1. Personnel Assessment Systems

Air Force job incumbents assigned to a wide variety of geographic locations and jobs.

Aptitude and adaptability requirements will be identified for selected occupational specialities. Aptitudes required for successful performance by Air Force enlisted personnel in training school and on-the-job will be identified. Aptitudes in the areas of computer abilities and administrative/clerical abilities will be examined, and measures of those aptitudes will be developed. The new measures will then be evaluated in terms of their reliability, validity, and utility for making selection and classification decisions. The Adaptability Screening Profile and the Assessment of Background Life Experiences will be examined for their utility in selecting those individuals who will most likely succeed in training and on-the-job. These individuals will presumably have a higher probability of being retained than individuals who have a lower probability of success, but this retention advantage will be determined empirically.



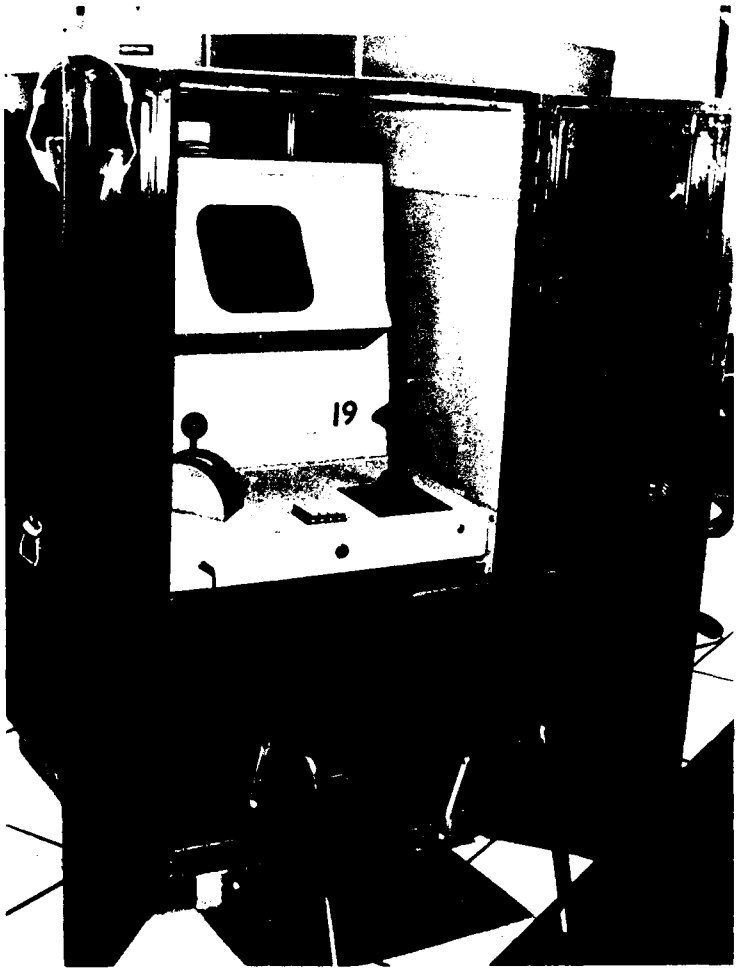
Productive capacity will be examined.

b. Productivity In Job Performance. The technology of measuring job performance in an effective and cost-efficient manner will be enhanced. Various factors that might influence productivity will be examined including training, experience, motivation, aptitude, climate, geographical location, and other individual or group characteristics. Research on productivity will be used to construct equally productive force structure alternatives for force structure planning and policy development. Optimal course lengths or other technical training resource investments will be analyzed for their impact on productivity. One promising measure of productivity, called "productive capacity" (estimated using supervisor ratings), is defined as "an individual's ability to be productive on the job in comparison with top performance by experienced personnel". Productive capacity will be examined for its utility and linked to selection and classification standards. This linkage will enable policy makers to set selection and classification standards based on the job performance (productivity) required to meet the needs of the Air Force.

c. Assessment Delivery Modes. The measurement of aptitudes and abilities via computer can be an important enhancement to the personnel testing program. Although an initial expenditure for hardware is required, benefits of using a computer-based mode for assessment include : (1) immediate scoring, data analysis, and feedback; (2) immediate checks for honesty of responding; (3) decreased administrative processing; (4) elaborate branching and targeting to the capacity of the respondent; (5) reduced need for scanning or hand-scoring answer sheets; and (6) improved assessment capabilities. Computer-based administration opens the door to the assessment of abilities not measurable in a paper-and-pencil mode (e.g., cognitive processing speed).

Before measures can be administered on a computer, R&D must be conducted to evaluate whether computer-based assessment is accurate, reliable, and valid for predicting training and on-the-job performance, as well as comparable to a paper-and-pencil mode of administration. Because not all facilities have computers, measurements must not be af-

fected by the method of assessment. Factors that will be examined include: (1) the display of items and instructions (for example, the way in which illustrations should be displayed, and the number of questions that should be displayed on a screen at one time); (2) optimal testing conditions in terms of eyestrain and physical comfort; (3) the time needed to read information on computer versus paper (exact time limits for computer administration will be determined); (4) equivalence of test scores (those conditions that make computer and paper-and-pencil modes of assessment comparable); (5) ways of minimizing the impact on individuals who may attain lower measurements due to unfamiliarity with computers; and (6) new measures, such as the time spent on items that are presented in three dimensions.



The Porta-BAT is widely used in pilot selection R&D.

d. Officer Ability Requirements. This R&D will identify the aptitudes required for the successful performance of Air Force officer tasks. It will result in profiles of basic abilities that are required within specific Air Force officer specialties. The identification of ability requirements will enable the development of selection tests that measure abilities of interest. Payoff is expected in the form of more accurate selection decisions, due to increased validity of job-related selection tests. Selection tests based on demonstrated job requirements are also more defensible against charges of unfairness.

Officer ability requirements will be determined at the task level for tasks identified as typical and important, based on available task survey data from the Air Force Occupational Measurement Center (USAFOMC). Subject-matter experts from a particular AFS will use ability rating scales to identify ability requirements specific to their AFS. This will result in ability profiles for new or revised AFSs, once a general pool of information is collected.

e. College Grade Point Averages (GPAs). College grade point average is routinely used in selecting candidates for Officer Training School (OTS). A study in FY 90 will identify ways in which differences in colleges can be measured. It will also estimate the degree to which these differences may influence the ability to predict performance in OTS from GPA.

f. Pilot Selection and Classification System (PSACS). AFHRL is developing an experimental computer testing system to enhance the ability of Air Training Command (ATC) to select and classify pilot trainees to meet the needs of Specialized Undergraduate Pilot Training (SUPT). When SUPT becomes operational in 1992, computerized testing, along with existing accession procedures, will be used to reduce attrition and allow classification into separate flying training tracks (bombers/fighters versus tankers/transports). Computer testing of OTS and Reserve Officers Training Corps (ROTC) pilot trainees undergoing undergraduate Pilot Training (UPT) at each of five ATC pilot training bases will be conducted. Training performance outcomes for use in test validation will be collected after UPT and after initial training on the pilot's first operational aircraft. Final design specifications for the experimental testing system will be delivered to HSD/YA in early 1991. The research methods will then be integrated into a full-scale development program which will produce a new-generation

operational computer testing device referred to as the Basic Attributes Test (BAT). During implementation, the BAT will be located at ROTC detachments and Military Entrance Processing Stations, where pilot applicants will be tested. Plans are for the BAT to become an operational part of the pilot selection and classification process in support of SUPT. AFHRL research in FY 92-95 will refine and improve selection and classification methodology using the BAT. The procedures will also be extended to other aircrew positions. The acquisition of cockpit skills will be tracked to determine how students' abilities affect learning progress in different phases of training. This R&D will increase our understanding of how measures of basic attributes can be used in aircrew selection and classification decisions.

g. LAMP Enhanced Selection Test Methods. Several years will be required to design and evaluate new learning skill tests based upon LAMP basic research program results. The tests must be validated over time. Examples of learning skill tests that might be developed are tests of working memory capacity and information processing speed.

2. MPT Requirements. Operational needs emphasize the technical challenge and urgency of integrating the various individual Manpower, Personnel, and Training (MPT) technologies. The MPT requirements subthrust (initiated in FY 86) will develop and evaluate the technologies, models, and data bases needed to support the use of MPT requirements information when weapon system design tradeoff decisions are made. The subthrust will also develop and evaluate various approaches to personnel and training pipeline and retraining systems for fielding new weapon systems, and will integrate MPT decision processes into existing systems. Prototype training systems for teaching problem-solving skills to airmen in high-technology specialties will be developed and evaluated. Because training and personnel management responsibilities are presently divided among several Offices of Primary Responsibility (OPRs), competing goals are often inevitable, and short-term fixes within limited areas can suboptimize total system effectiveness. The primary goal is to provide a unified approach to defining job specifications and training requirements. These are seen as the essential foundation for all major personnel management functions. Success in the integration of MPT decision processes is expected on the basis of past successes in component R&D areas.

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Figure 2 outlines the plans in this area. Major areas within the MPT requirements subthrust are:

a. New MPT Technologies. The central effort in the MPT requirements subthrust is the work on new MPT technologies. Examples of new technologies being addressed are: the evaluation of more flexible and effective Air Force Specialty Code (AFSC) structures (FY 90); and exploratory research on using artificial intelligence methods to help project the MPT requirements of new weapon systems (FY 91).

b. Projecting MPT Requirements. The exploratory work described above will lead to an advanced development program concerned with projecting MPT requirements. Key products will be: development of an aptitude requirement estimator (FY 91); advanced software for the interface between Logistics Systems Analysis (LSA) and Instructional Systems Development (ISD) (FY 92); procedures for simulating Air Force specialty (AFS) structures for specific situations (FY 92); a personnel availability forecaster (FY 93); a model for estimating transferability of skills (FY 94); and a Total Force Impact Model (TFIM) to aid MPT planners in balancing the MPT constraints for new weapon systems against available Air Force-wide resources (FY 94).

c. New Methods for Analyzing Occupational Data. Important inputs for the work on projecting MPT requirements will be provided by new methods for analyzing occupational data (FY 90-93). The needs

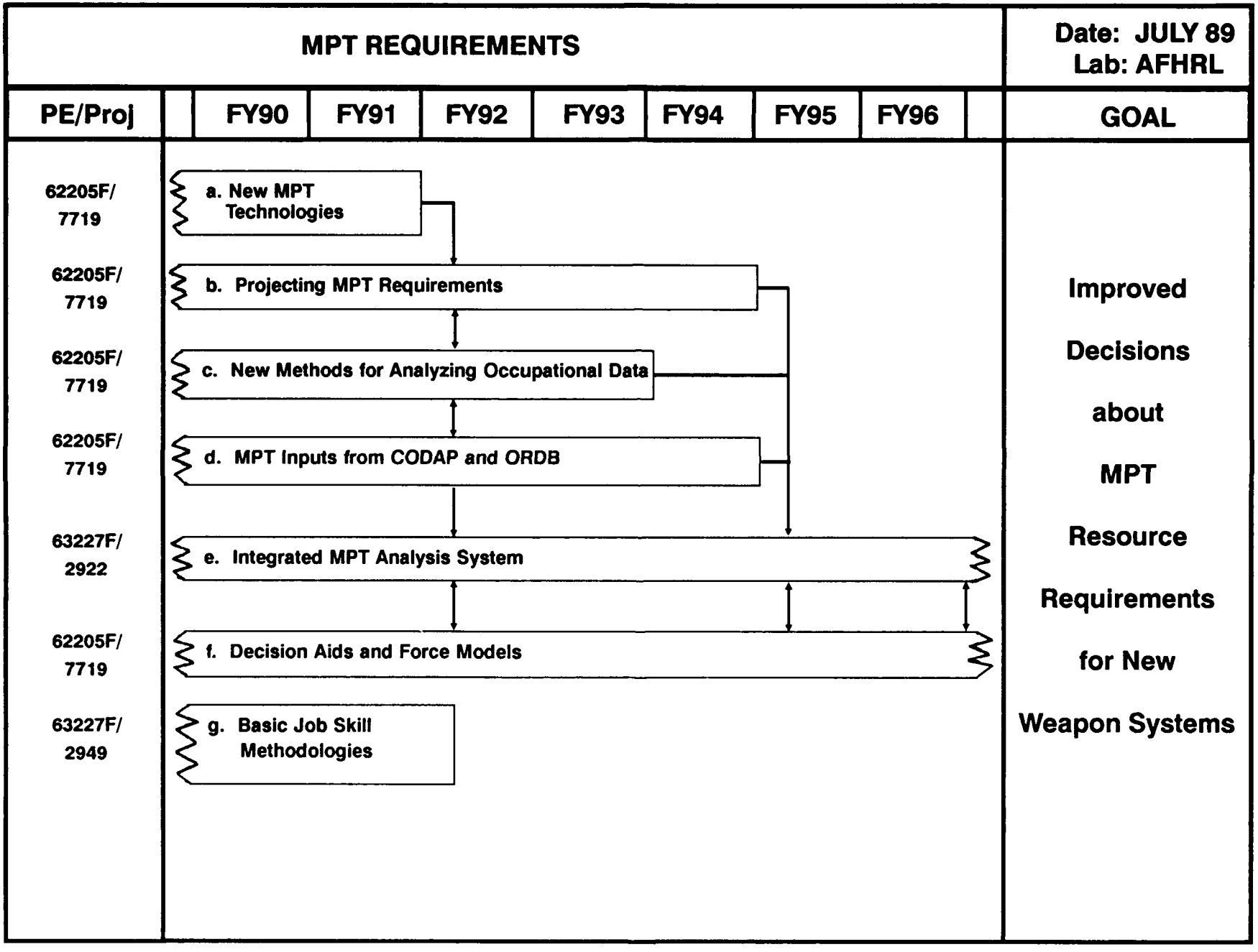
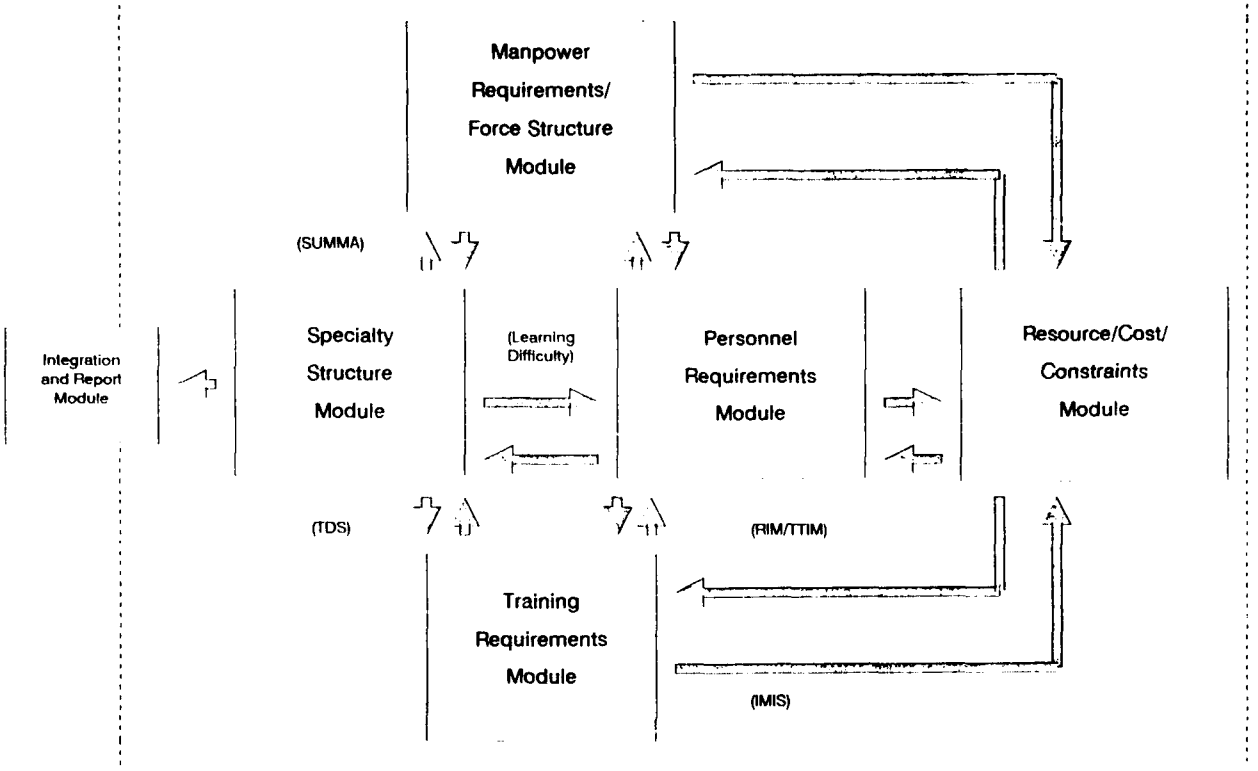


Fig 2. Manpower and Force Management Subthrust MO-2. MPT Requirements

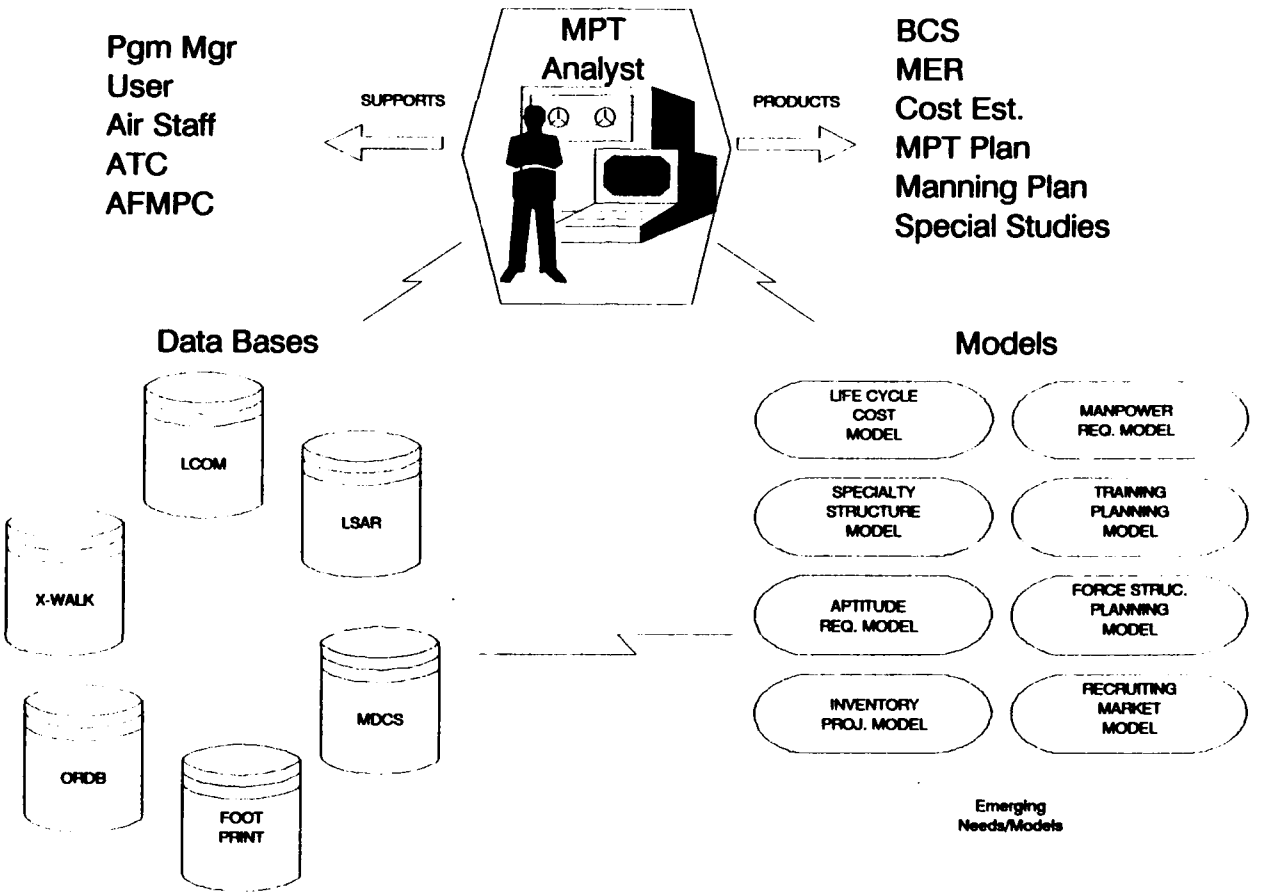
ARCHITECTURE FOR SPECIALTY STRUCTURING SYSTEM (S^3)



of the Air Force Occupational Measurement Center (USAFOMC), the Air Force Military Personnel Center (AFMPC), and the Air Staff for occupational data base management will be investigated, particularly as they relate to MPT integration. Those needs that cannot be met by the existing Occupational Research Data Bank (ORDB) will be considered for inclusion during future developments. The use of artificial intelligence (expert systems) in analyzing occupational data will be explored. The development of automated test outlines for use in the Weighted Airman Promotion System (WAPS) test development process will provide significantly better job relatedness and knowledge-based tests (FY 90). Currently, occupational data are collected and analyzed by Air Force specialty. New efforts are under way to do this by weapon system, providing additional information to Air Force decision makers (FY 90-92).

d. MPT Inputs from CODAP and ORDB. Enhanced capabilities will be developed for profile analysis, multidimensional scaling, regression analysis, and factor analysis. Work on expert systems of job analysis will be conducted, including search and heuristic techniques, pattern recognition, semantic information processing, and graphical methods of data analysis and presentation. With the aid of these new methods, it will be possible to develop advanced MPT inputs using Comprehensive Occupational Data Analysis Programs (CODAP) and the ORDB (FY 90-94). Because occupational data are currently collected and analyzed by Air Force specialty, several new efforts are designed to make the CODAP and ORDB data available in a weapon system format, rather than a specialty format (FY 90-92).

MPT ANALYSIS SYSTEM



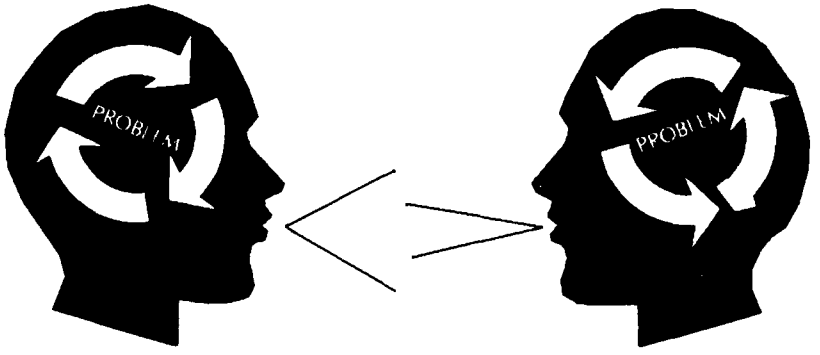
LEGEND

MPT--Manpower, Personnel , & Training
Pgm Mgr--Program Manager
ATC--Air Training Command
AFMPC--Air Force Military Personnel Center
BCS--Baseline Comparable System
MER--Manpower Estimate Report
Cost Est--Cost Estimate
LCOM--Logistics Composite Model
LSAR--Logistics Support Analysis Records
MDCS--Maintenance Data Collection System
ORDB--Occupational Research Data Bank
X-Walk--Cross Walk

e. Integrated MPT Analysis System. An advanced development (6.3) project has been established to pull together the inputs provided by a variety of different efforts in the MPT requirements subthrust and will result in the additional work needed to make these products useful for Air Force purposes. Existing data bases will be expanded and consolidated. Models will be tested in new applications, and advanced versions of analytical models will be organized into decision support systems. These decision support systems will eventually be used by MPT planners in the product divisions of AFSC and/or the aggregate systems planning shops of the Air Staff. Most of the studies will focus on the utility of new tools and data bases for MPT forecasting decisions. Milestones are: consolidation and linkage of existing AFHRL tools and data bases (FY 90); consolidation and linkage of selected non-AFHRL tools and data bases (FY 91); development of support systems for use in MPT planning decisions during weapon system development (FY 93); and development and integration of weapon system optimization models (FY 96).

f. Decision Aids and Force Models. Decision systems and models are important parts of the MPT requirements subthrust. They provide managers at all levels with tools to make important decisions about competing MPT resources. Examples of models to be developed are: a retraining person-job-match (PJM) model for both volunteer and non-volunteer retrainees (FY 91); a PJM model for career enlistment assignments (FY 93); a prototype officer accession/assignment model (FY 93); a prototype civilian availability model (FY 90); several models for determining manpower requirements to support and maintain emerging weapon systems (FY 93-97); a joint accession/retention enlisted labor market model (FY 91); a demographic trend/impact estimation model (FY 93); an extended productivity measurement and enhancement model linking laboratory productivity research with DOD-directed total quality management objectives (FY 93); and a civilian labor market model (FY 95).

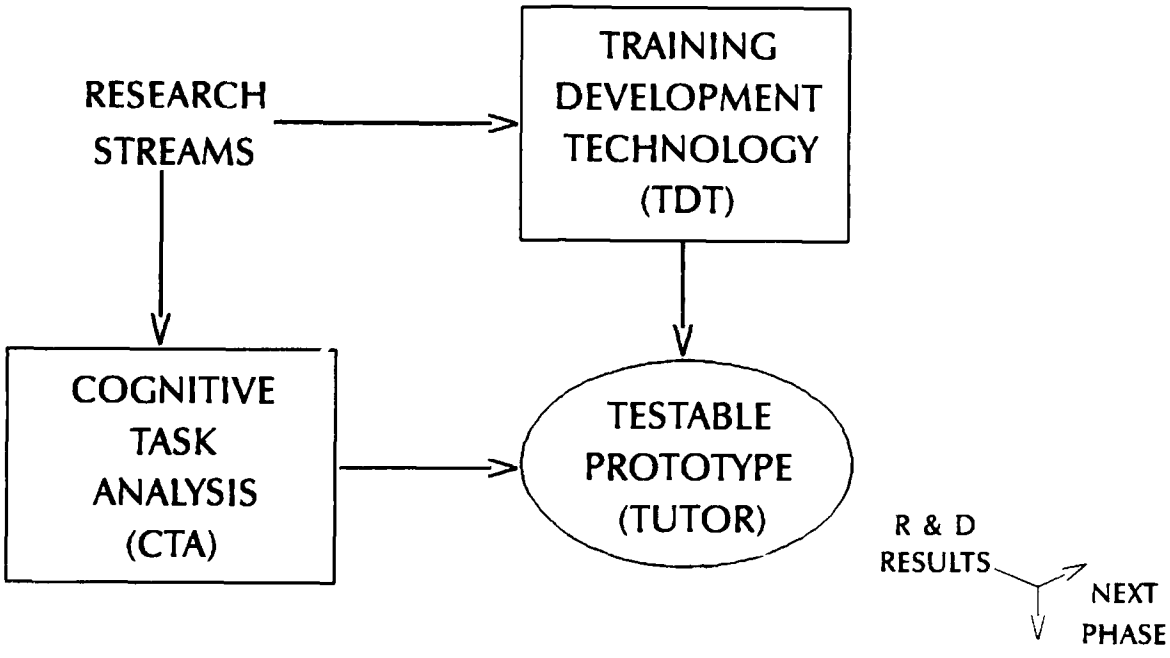
APPROACH



- THEORIES OF EXPERT PROBLEM SOLVING
- PROCEDURES BASED ON ADVANCES IN ARTIFICIAL INTELLIGENCE TO SPECIFY HOW EXPERTS SOLVE PROBLEMS → *COGNITIVE TASK ANALYSIS TECHNOLOGY*
- PROCEDURES BASED ON PRINCIPLES OF APPRENTICESHIP TRAINING TO TURN EXPERT KNOWLEDGE INTO LEARNABLE CONTENT FOR TRAINING → *TRAINING DEVELOPMENT TECHNOLOGY*

g. Basic Job Skills (BJS) Methodologies. This R&D will assess and measure the basic job skills that first-term airmen need to gain proficiency in high-technology (high-tech) Air Force specialties. "Basic Job Skills" are defined as " the core knowledge and thinking processes that underlie apprenticeship competence across the most technically demanding jobs in the Air Force." The exploratory development work in the BJS effort is concerned with three things: using recently developed cognitive task analysis techniques to determine the problem-solving skills and knowledge needed by airmen; developing diagnostic achievement tests to determine what an airman knows, and then prescribing a training regime; and designing specifications for training in high-tech specialties (FY 90-91).

R & D APPROACH



Logistics Technology

General Objective

Logistics technology R&D will develop methods to design more supportable (reliable, maintainable, operable, and affordable) weapon systems; will develop specifications for a fully integrated maintenance job aiding and fault diagnostics system; and will provide more effective ways of performing combat maintenance. These programs provide key technology necessary to achieve the DOD Computer-Aided Acquisition and Logistics Support (CALS) initiative.

AFHRL work in logistics systems technology development supports both CALS and SE.

This technical area focuses on using information systems technology to enhance logistics processes which include the design, acquisition, operation and maintenance of weapon systems. Improved information systems should allow Air Force personnel to access quickly the information needed for immediate decisions or tasks. Integration of information systems requires better methods for identifying requirements of Government and industrial users; for interfacing computers for exchanging information among data bases; for authoring, storing, updating and presenting data; for developing decision support systems to help use these data; and for modeling, analyzing, and displaying information. Research underway covers a broad spectrum; it ranges from human information processing to the use of artificial intelligence and to data base organization. Planned technology developments will influence the design and acquisition of new weapon systems. They also will provide technicians with computer-based aids for maintaining weapon systems under austere deployment conditions.

Specific Goals and Technical Approaches

1. Logistics Systems. Two high-level initiatives are spurring work in logistics systems. The Computer-Aided Acquisition and Logistics Support (CALS) program is a multi-Service program directed by the Office of the Secretary of Defense. The new Simultaneous Engineering (SE) program has been combined with the Unified Life Cycle Engineering (ULCE) program to form a critical part of the Air Force Systems Command's effort. The CALS program and the SE program have complementary goals. CALS seeks to achieve improved supportability and sustainability. It aims to integrate and automate much of the acquisition support process by networking Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) processes. The SE program aims to develop and demonstrate an efficient, systematic approach to creating the design of high quality products. It also aims to develop and demonstrate efficient, systematic processes for producing and supporting them. It is an integrated design engineering process which engineers the product and its manufacturing and support processes at the same time. SE

emphasizes efficiency, increased quality and reduced costs. AFHRL work in logistics systems technology development supports both CALS and SE.

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Figure 3 outlines the plans in this area. Major areas within the Logistics Systems Technology subthrust are:

a. Information Engineering. Engineering and manufacturing processes generate and maintain large volumes of technical data in independently developed systems. They often use different operating systems and data base management systems. Because the systems do not share data, it is difficult to manage and control critical information throughout the product life cycle. This R&D will analyze existing information system specification and design methods to identify the technologies required to integrate the information needed for simultaneous engineering activities. Methodology development and tool development will continue through FY 94.

AFHRL is identifying technologies required to integrate the information needed for simultaneous engineering activities.

b. Integrated Design Support (IDS) System. IDS is an information system R&D program whose goal is to improve the capture, management, use, and dissemination of weapon system technical data. The IDS program is developing an information architecture and a prototype software system that will allow the automated storage, retrieval, and configuration management of engineering data from design engineering through manufacturing to maintenance and sustaining engineering. The initial development and demonstration will focus on the composite structure design of the B1-B. The DOD does not now get or keep sufficient technical information for the complete logistics support (remanufacturing, third-party parts suppliers, replacements for obsolete parts, etc.) of most weapon systems. As a result, DOD is dependent on primary contractor support throughout the life of the weapon system. The IDS program is one part of a larger information technology demonstration being pursued by AFHRL/LR and the Manufacturing Technology Directorate at the Wright Research and Development Center (WRDC/MTI).

c. Productivity Improvements in Simulation Modeling (PRISM) Project. The goal of this project is to improve logistics capability assessment models. AFHRL's goal is to replace the Air Force's current use of inefficient and rigid large-scale simulation models with a modeling environment based on an object-oriented knowledge base and high-level modeling tools. The modeling environment will be graphics-based and will enable logistics analysts to customize their models to their own particular problem.

d. Computer Model of a Maintenance Technician (Crew Chief). The Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL) and AFHRL are developing a computer graphics model of Air Force technicians for use in evaluating the maintainability of future weapon systems. This program is building anthropometric

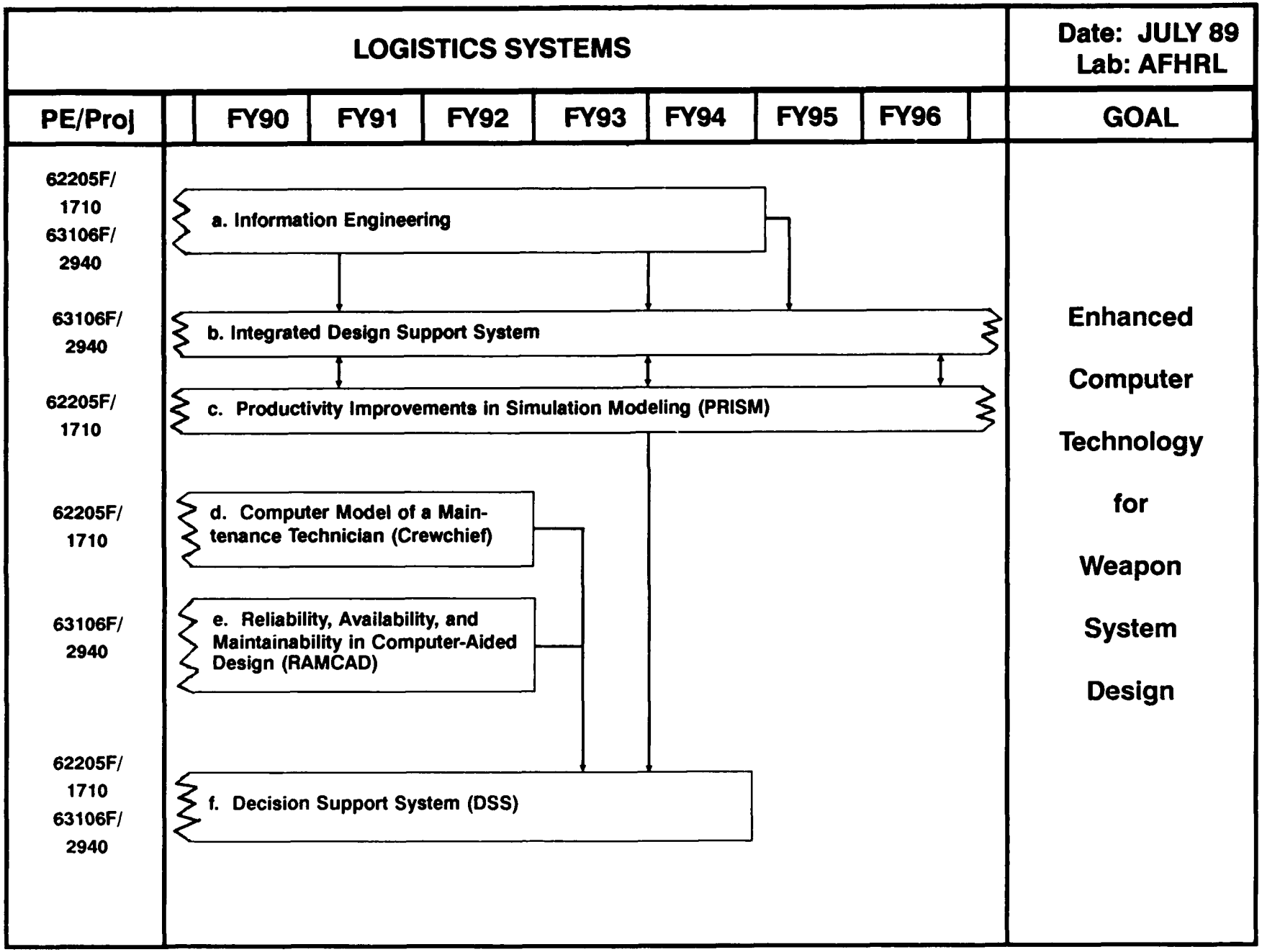
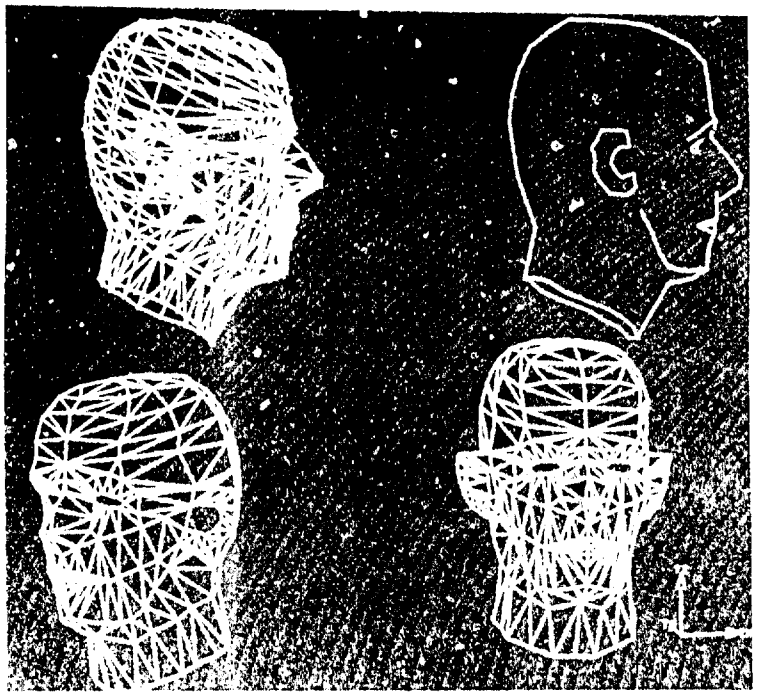


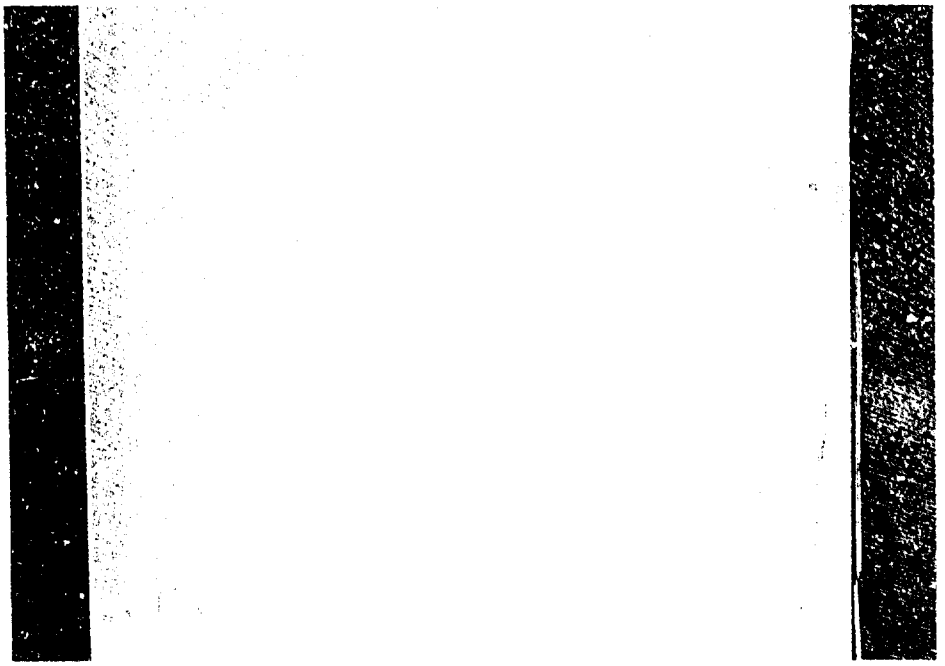
Fig 3. Logistics Technology Subthrust LR-1. Logistics Systems



Crew Chief is building anthropometric models of Air force maintenance technicians.

models of Air Force maintenance technicians to perform better maintainability assessments during weapon system design. The model interfaces with existing commercial computer-aided design (CAD) systems used by aerospace manufacturers. The goal of Crew Chief is to give CAD designers the ability to simulate maintenance and other related human operator interactions during weapon system design. Long-range plans are to make Crew Chief fully dynamic, with task time estimation and task analysis capabilities. AFHRL will increase the efficiency and user-friendliness of Crew Chief by integrating the Crew Chief data with CAD computer routines. Doing so will allow task analysis and time analyses to be performed automatically. The project consists of five major phases: (1) animation (FY 90); (2) collision detection/avoidance (FY 90); (3) human factors analysis (FY 91); (4) activity modeling (FY 90-92); and (5) time estimation (FY 92).

e. Reliability, Availability and Maintainability in Computer-Aided Design (RAMCAD). This effort will develop analytical models, computer software, data bases, and work procedures that will enable maintenance and logistics factors to be included in the computer-aided design of systems and equipment. Computer-aided engineering techniques have helped reduce design times. They also have created opportunities for engineers to consider the reliability and maintainability of systems during the initial design phases. A wide spectrum of CAD technologies for industrial design are being developed in the commercial market. These CAD technologies enhance drafting capabilities and the hardware design process. Due to the fact that maintenance and logistics considerations are not formally a part of the drafting process, industry has little motivation to include these considerations into their CAD systems. RAMCAD provides the only USAF funding for such efforts. RAMCAD will develop and demonstrate interactive computer techniques to design and evaluate the maintenance and logistics characteristics of weapon systems within a CAD environment. It includes demonstrations on ongoing weapon system development programs. Two RAMCAD efforts focus on providing solutions to long-

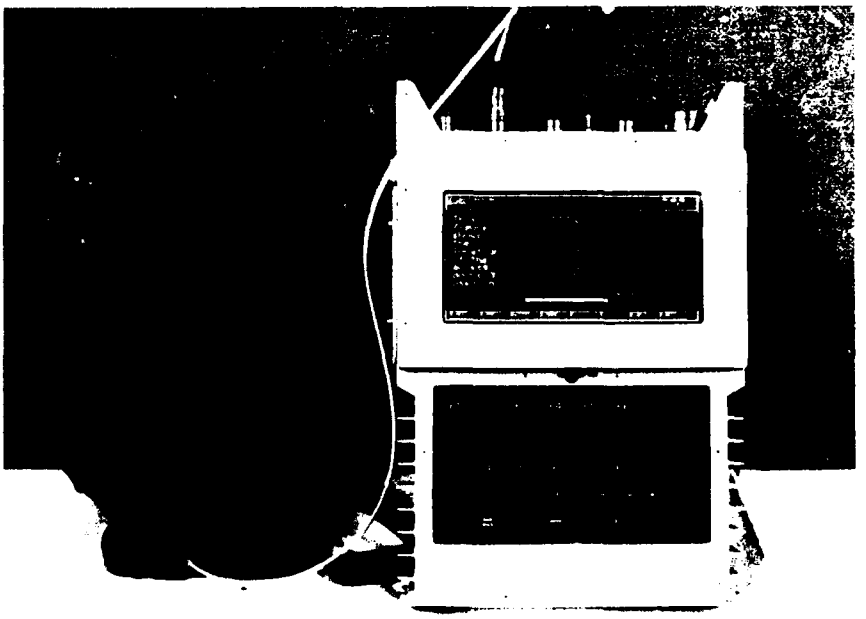


Aircraft maintenance will be enhanced by development of Crew Chief model.

standing weapon system reliability, maintainability, and supportability (RM&S) problems. Their goals are to provide designers with an environment to use automated supportability tools. The first, a near-term effort, is developing a prototype RAMCAD system. It will integrate a minimum of three different RM&S software models within a CAD system. Doing so puts tools in the hands of electronic, mechanical and structural designers. The second effort is long-range R&D to aid electronic system designers. It will aid them in optimizing their designs by using the proper analyses, rules, and constraints at each phase of design. Initial contract work will be completed in FY 90, with follow-on test-bed and workstation development continuing through FY 92.

f. Decision Support Systems (DSSs). This work is composed of several efforts to develop decision support system technologies. The DSS technologies will aid Air Force design teams in considering system design attributes and will allow them to arbitrate between conflicting design goals. Key enabling technologies derive from formal design methods, data base structures, data base management systems, tradeoff analyses, and expert system design tools. The DDS effort will focus on their prototyping, test-bed implementation, and proof-of-concept demonstration. AFHRL completed development of decision support architecture/integration requirements in September 1987, and provided them to RAMCAD contractors. System engineering and measurement efforts began during FY 87. Current plans call for a 36-month program focused on examining the problem of multi-criterion RM&S analysis during the design cycle (FY 92). The Laboratory also is planning to define a knowledge-based architecture that gives the designer a highly interactive analysis capability for optimizing design requirements at any level of system assembly (FY 94).

2. Integrated Maintenance Information System (IMIS). Changes in threats, support concepts, and weapon system technology are altering radically the ways aircraft maintenance will have to be accomplished in future wars. Aircraft will have more complex systems and will operate from small, dispersed locations. They will depend less on bulky test equipment and large on-site facilities. There probably will be fewer technicians. Each will have to master a broader range of tasks and skills. Also, the Air Force's conventional technical orders (TOs) are often incomplete, poorly organized, and difficult to use. To address these problems, AFHRL/LRC is developing a comprehensive information and job aiding system to help maintenance technicians support the sorties needed in future combat environments. Since 1976, AFHRL has developed and tested technology for electronic technical data presentation systems, techniques, and procedures.



AFHRL has developed and tested technology for electronic technical data presentation systems, techniques, and procedures.

The Laboratory has focused its effort on making it easier to perform maintenance in a deployed combat environment. The final product of this work will be draft military specifications which will describe the functional requirements of an IMIS and outline how to adapt it to various weapon systems and maintenance concepts. The specifications will cover technical orders, diagnostic aids, a training subsystem, and a management information subsystem. They will include information format, content, and display requirements. The specifications will define the human factors and human-machine interface requirements for the system. These specifications and standards will reflect data developed both

through in-house work and through field tests using operational weapon systems. IMIS will interface with and support other existing and planned base-level maintenance information systems. It will link existing and developing flightline systems with a computer-based technical information system. The IMIS program is closely coordinated with the Air Force Logistics Command (AFLC) Air Force Technical Order Management System (AFTOMS), as well as other related DOD initiatives. IMIS also will provide diagnostic job aids to help technicians troubleshoot. It will interface with on-board aircraft computers. A major application of this technology will be the Advanced Tactical Fighter (ATF). IMIS will have several benefits. It will improve the use of available personnel and will enhance their technical performance. IMIS will reduce the support equipment and technical documentation needed for deployment and will improve training. The Air Force could realize significant cost savings from reduced formal training. Perhaps most significantly, IMIS's diagnostic capabilities will allow technicians to troubleshoot faults more rapidly and accurately. As a result, maintenance personnel will be able to return aircraft sooner to operational use and will use fewer spare parts.

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The roadmap for the IMIS subthrust is at Figure 4. Major areas of work are as follows:

a. IMIS Functional Requirements Definition. AFHRL is developing a formal requirements definition for the tactical environment. The Laboratory will turn these formal requirements into prototype hardware and software, which will be tested in the field in 1993. The test is expected to demonstrate the full capabilities of the integration of all of IMIS's technical and management functions.

b. IMIS Diagnostic Demonstrations (IMIS-DD). This effort will develop an integrated diagnostic system for IMIS, using the F-16, F-18, and X-29 aircraft as test systems. It will result in a first-generation system. The system will have a control structure for calling up test procedures. It will also have a mechanism for flagging and enhancing the data base where it is insufficient to isolate a failure. The system also will have a capacity for explaining the logic of tests to its users. AFHRL carried out a successful field test on the F-16 fire control radar in May 1989. A more complete field test will use the Navy F/A-18 aircraft and take place in late 1990.

c. IMIS Draft Specifications. To achieve the integrated information required to support both CALS and technical information systems, DOD must implement specifications and standards for the creation, storage, transmission and use of digital technical information. A major aim is to develop specifications so maintenance technicians can use the systems effectively. This effort includes the development, field demonstration, and evaluation of content, format, user interface, and data base structure. It will cover the functional requirements for hardware and integrating software.

d. Authoring and Presentation System (APS). This effort has produced the capability to author and present IMIS technical data. APS uses a "neutral" data base, which allows the data to be presented on a variety of hardware systems. (By contrast, most authoring systems permit the data to be presented on only one hardware system.) Several major Air Force and Army weapon systems are using the APS to author digital data. Work has recently begun to rewrite APS in an object-oriented language. Rewriting will ensure that APS can accommodate functional/physical modeling capabilities and diagnostic data base requirements. A rewritten APS also could support the requirements for aircraft battle damage assessment (ABDA) and aircraft battle damage repair (ABDR).

e. F/A-18 Field Demonstration: In the F/A-18 field demonstration, AFHRL is working with the Navy to develop and test an on-aircraft interactive diagnostic capability. This work, scheduled for completion in FY 91, will involve a more extensive test of the systems developed and tested on the F-16.

f. Full IMIS Development and Demonstration: AFHRL is developing a complete IMIS system, which will integrate and display all of the maintenance information important to the flightline technician in future dispersed maintenance environments. It will be field-tested during FY 93. This project will analyze the total information requirements for future maintenance environments. It will develop and field-test a complete information system to meet those requirements. This project

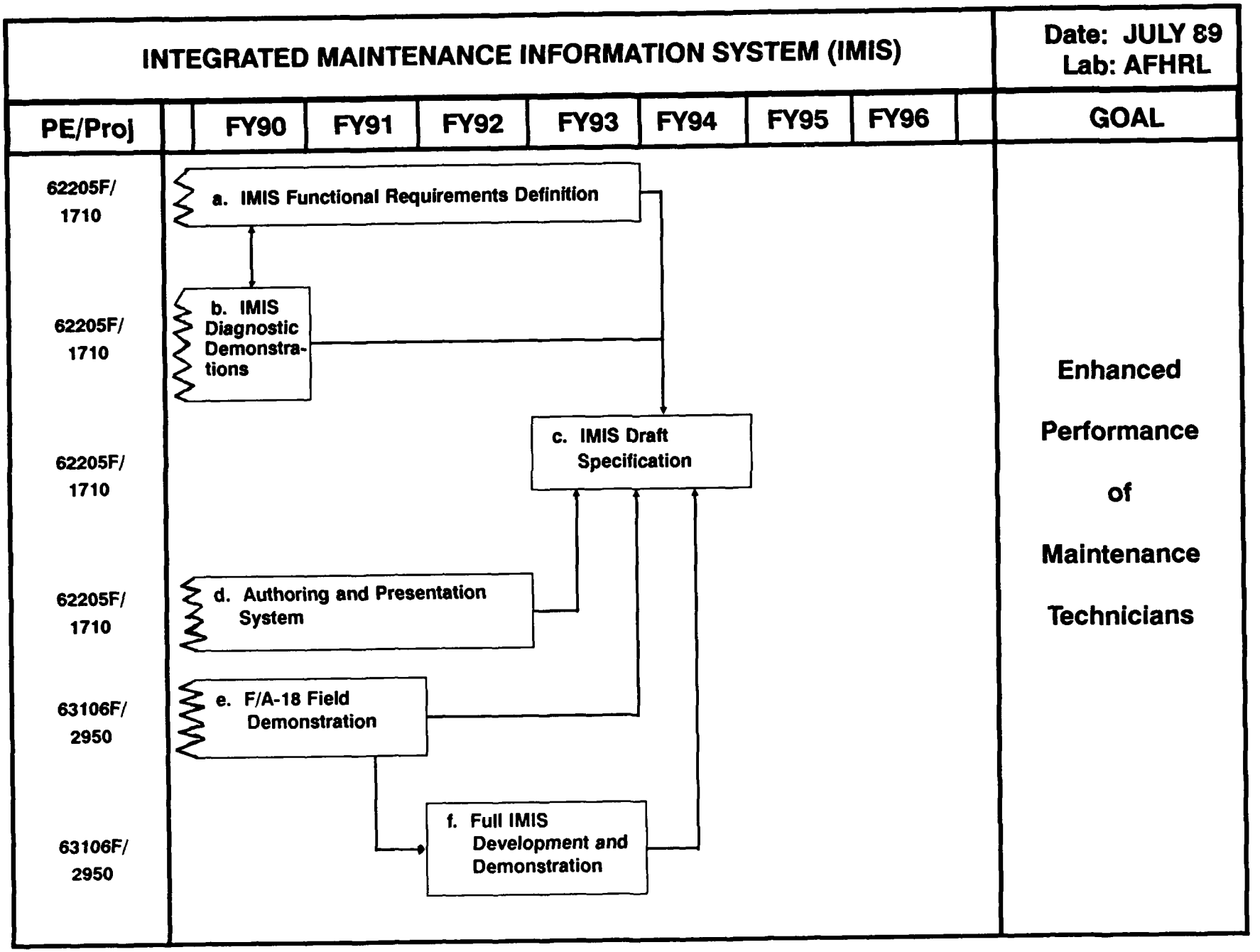

Fig 4. Logistics Technology Subthrust LR-2. Integrated Maintenance Information System

will produce by FY93 the functional specifications for the full-scale development of an IMIS system.

3. Combat Capability Assessment. This R&D will improve the readiness and capability of maintenance units to sustain high aircraft sortie rates under wartime conditions. AFHRL is developing methods to determine which tasks are essential to combat and how organizations and procedures differ in peacetime and combat conditions. The Laboratory will use the information to improve combat-oriented operating practices and training programs. The effort will build upon recently completed work on AFSC restructuring and aircraft maintenance in chemical warfare environments.

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A roadmap for the work in this subthrust is at Figure 5. Major areas of work are as follows:

a. Maintenance Limitations in a Chemical Warfare Environment. This R&D will develop a methodology for identifying maintenance capabilities and limitations in a chemical warfare environment. Research products will include task performance times for the chemical defense protective suit, recommendations for equipment and training improvements, and work-arounds for difficult problems. Analyses to determine whether technicians can learn to adapt to tight locations, awkward access areas, and other difficult task circumstances are now in process. The analyses also are addressing how much these accommodations will transfer to tasks with similar characteristics. If results are successful, a training program could specify which tasks to practice in chemical protective gear so that technicians will be able to perform a much larger set of maintenance tasks.

b. Impacts of Stress. The objective of this work is to examine the feasibility of various approaches to reducing the occurrence and potential impacts of stress in aircraft maintenance organizations. In FY 89, AFHRL rated and prioritized the approaches based on factors such as their cost effectiveness, their implementation difficulties and their probabilities of success. The Laboratory is planning a follow-on field test to further develop and test the approaches.

c. Combat Data Analysis. This effort, which is scheduled for completion in FY 91, aims to develop an integrated combat data base using actual exercise data from U.S. and foreign sources. The data base can be used to depict actual combat conditions. It will be used by analysts to determine wartime requirements and sortie capabilities.

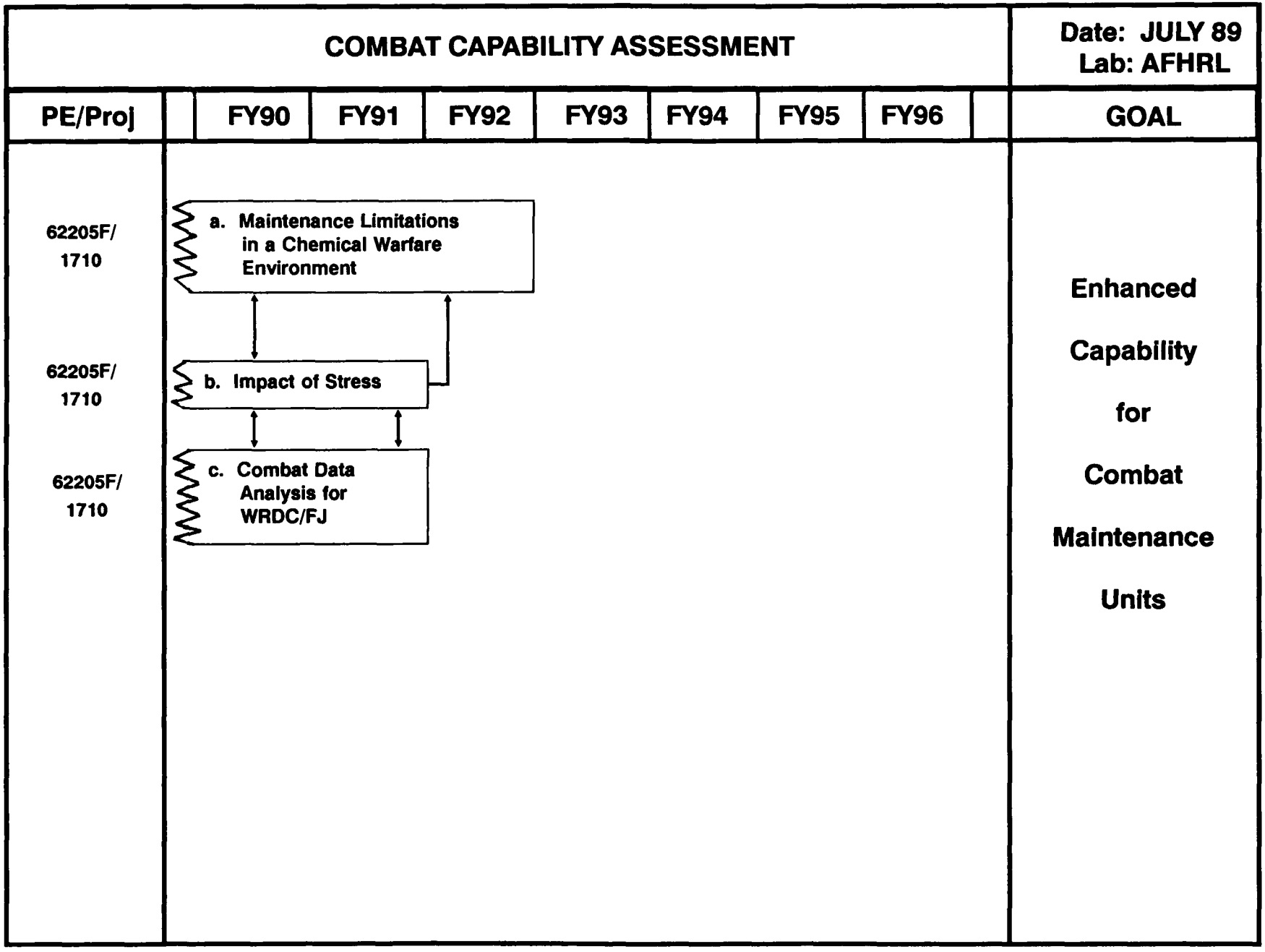

Fig 5. Logistics Technology Subthrust LR-3. Combat Capability Assessment

AFHRL R&D will develop a methodology for identifying maintenance capabilities and limitations in a chemical warfare environment.

Training Technology

General Objective

The goal of training R&D is to increase combat readiness and job performance by developing and demonstrating more cost-effective ways of acquiring and maintaining new skills. AFHRL develops new training strategies and systems that result in increased combat readiness and higher quality job performance. The improvements in combat readiness focus on reducing early loss rates and increasing survivability, so that more equipment and personnel will be available for subsequent combat efforts. Improved cost effectiveness would make it possible to train more personnel to high levels of performance and permit more efficient use of limited training resources.

Specific Goals and Technical Approaches

1. Aircrew Training Requirements. The drive toward lower-cost aircrew training will be advanced by improved techniques for identifying training requirements and designing simulators. The application of new aircrew training systems and simulation techniques will permit savings by providing high quality training in cost-effective ways. Important goals for aircrew training are to identify the amount of simulator fidelity required and to determine the extent to which specialized training system characteristics should be used to help enhance training. This information is needed to help designers of Air Force training systems decide, "How much is enough for a given task?"

AFHRL developed specifications to better define and integrate all phases of flying training.

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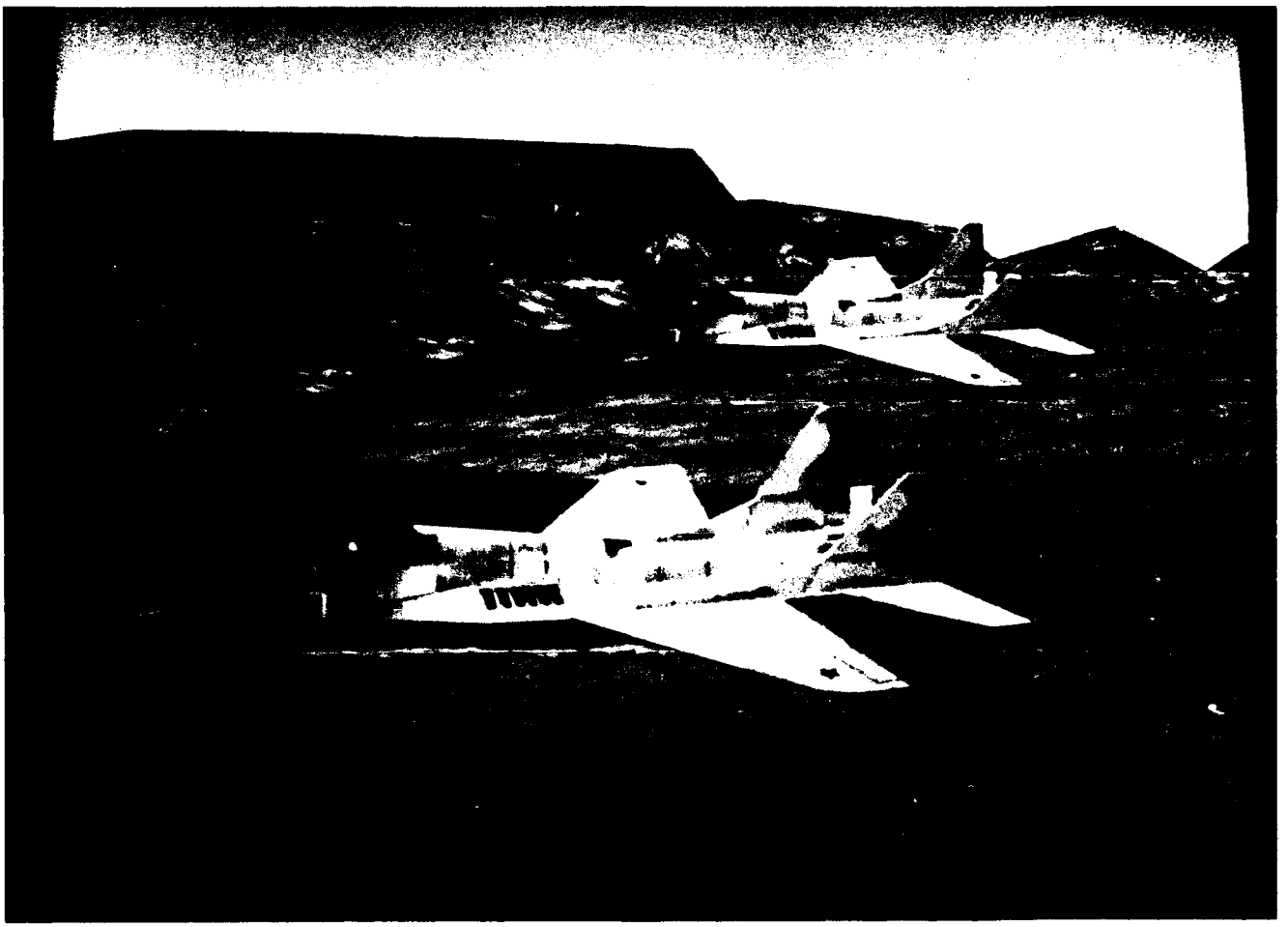
A roadmap for the plans in this area is at Figure 6. Important areas of work are as follows:

a. Training System Design Guidelines. Specifications were developed to better define a spectrum of training media, and integrate all phases of training. Military Airlift Command (MAC) and AFHRL have incorporated these concepts into the C-130 Aircrew Training System (ATS). The program includes an evaluation of the ATS and its major elements, as well as an R&D component to address cost-effectiveness issues in the context of the C-130 ATS. Similar programs are being developed for the B-52/KC-135 formal school. Collectively, these programs will contribute to guidelines for designing training systems that fully use the capabilities of a given training device, integrate differing media in cost- and training-effective ways, and can be used to design total training systems to coordinate all phases of training. A report describing lessons learned and findings from the C-130 ATS will be published in FY 91. The training guidelines should be useful in a wide variety of aircrew training systems as a total training systems design manual.

b. Visual Scene and Display Requirements. Additional efforts will be conducted in the visual fidelity area during FY 90-91. During FY 90, work will be completed on: criteria for tactical simulator display brightness; criteria for simulator display resolution; specification of skill requirements for various levels of target detail; and a handbook of visual scene requirements for training FY 92 low-level flight skills. This handbook will be partly based upon the perfor-



AFHRL is developing a handbook partly based upon the performance of pilots in a variety of visual scene conditions.

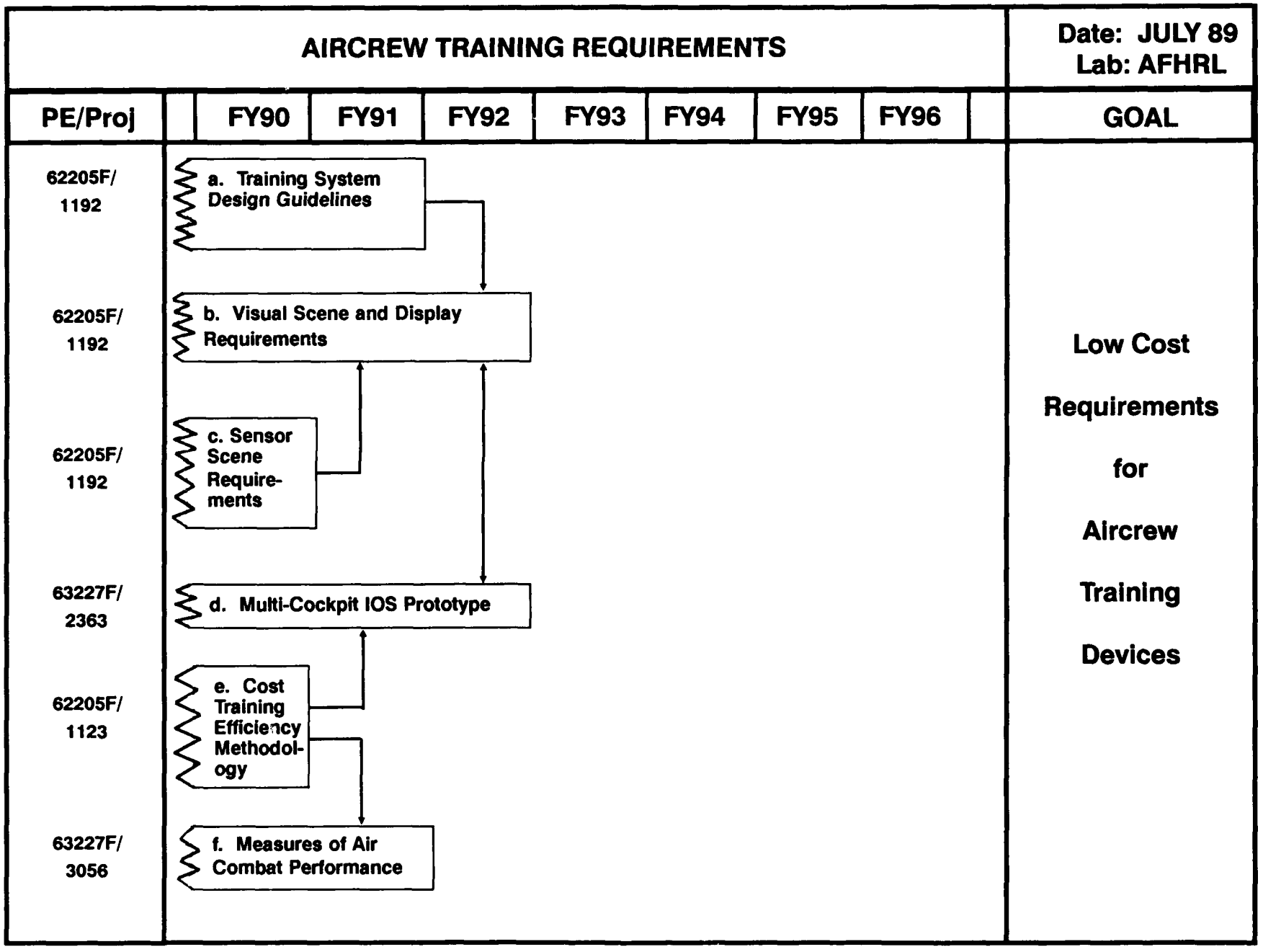


Fig 6. Training Technology Subthrust OT-1. Aircrew Training Requirements

Studies will evaluate the ability of subjects to determine basic characteristics of ground targets.

mance of pilots in a variety of visual scene conditions. Differing textures, 2- and 3-dimensional object types and densities, sizes of objects, shadings, shadows, and atmosphere attenuation will be explored. During FY 90, a supplemental report will be completed containing recommendations regarding the use of color in flight simulation.

c. Sensor Scene Requirements. During FY 90, studies of infrared and radar image fidelity will be conducted. One set of studies will evaluate the ability of subjects to determine basic characteristics of ground targets, such as orientation and classification, as a function of sensor image fidelity. Another set of studies will determine the amount of simulated infrared scene fidelity needed to train low-altitude terrain-following and navigation tasks.

d. Multi-Cockpit IOS Prototype. During FY 90-92, work will be conducted on multi-cockpit Instructor Operator Station (IOS) designs and modular IOS software. The multi-cockpit IOS will be capable of interfacing with subsequent prototype configurations of in-house cockpit simulators (up to 14) by FY 92. The modular software (developed in FY 90 as part of a joint-Service program) will be a standard IOS software package applicable to simulation in general.

e. Cost/Training-Effectivness Methodology. This issue is primarily concerned with the design and implementation of a data base that can be used to consolidate existing information about cost/training-effectiveness relationships and make it available when cost tradeoff decisions must be made. Most of the work in this area is being conducted by the Army Research Institute (ARI) and the DOD Training and Performance Data Center (TPDC). ARI has been developing a model for the Optimization of Simulation Based Training Systems (OSBATS) since FY 86. AFHRL is providing data for

Work will be conducted on multi-cockpit Instructor Operator Station designs.

use in testing this model. Although OSBATS is not yet complete, the model is expected to provide a comprehensive way of estimating the cost/training effectiveness of aircrew training simulators by FY 90. The computer model, when fully refined, will provide a way of determining optimum points on the simulation cost-versus-fidelity curve. TPDC is responsible for incorporating training-effectiveness data into TPDC data bases when the data are ready for this transition.

f. Measures of Air Combat Performance. The objective is to validate and refine techniques for assessing air combat performance using the Air Combat Maneuvering (ACM) Performance Measurement System (PMS). The PMS was developed for the Simulator for Air-to-Air Combat (SAAC) and the Air Combat Maneuvering Instrumentation (ACMI) range. The R&D will identify and implement alternative scoring techniques. It will also collect data that reflect the relative validity of these alternative scoring procedures. Upon completion of the F-15 beyond-visual-range PMS, this work will be transitioned to the F-16. The end products in FY 91 will be techniques and procedures for measuring air combat performance.

2. Aircrew Training Technology Development. The mission of AFHRL includes the design, development, and evaluation of new methods, equipment, and simulator devices for use in aircrew training.

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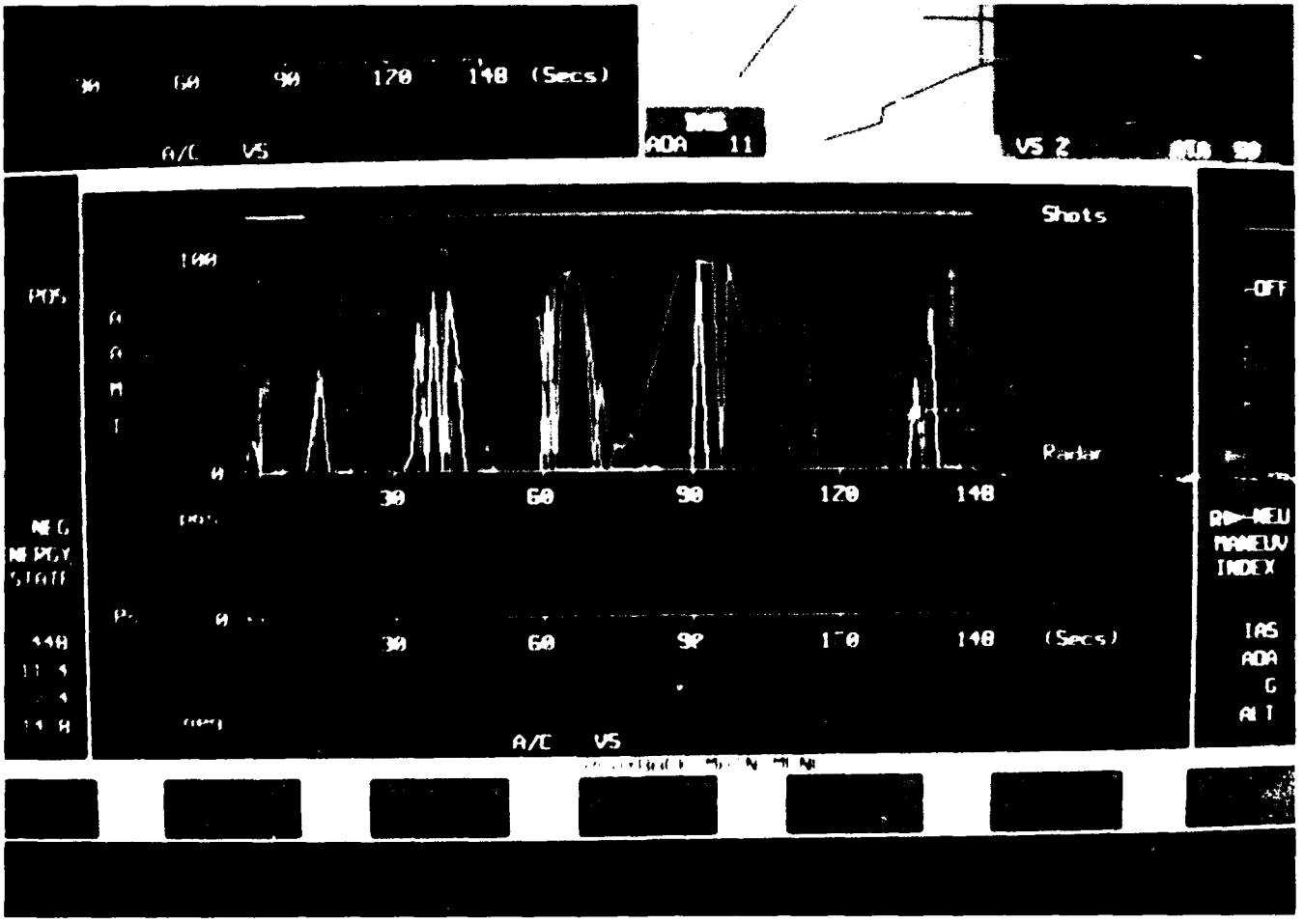
Several efforts are planned in the subthrust, as illustrated by the roadmap shown in Figure 7.



AFHRL is validating and refining techniques for assessing air combat performance.

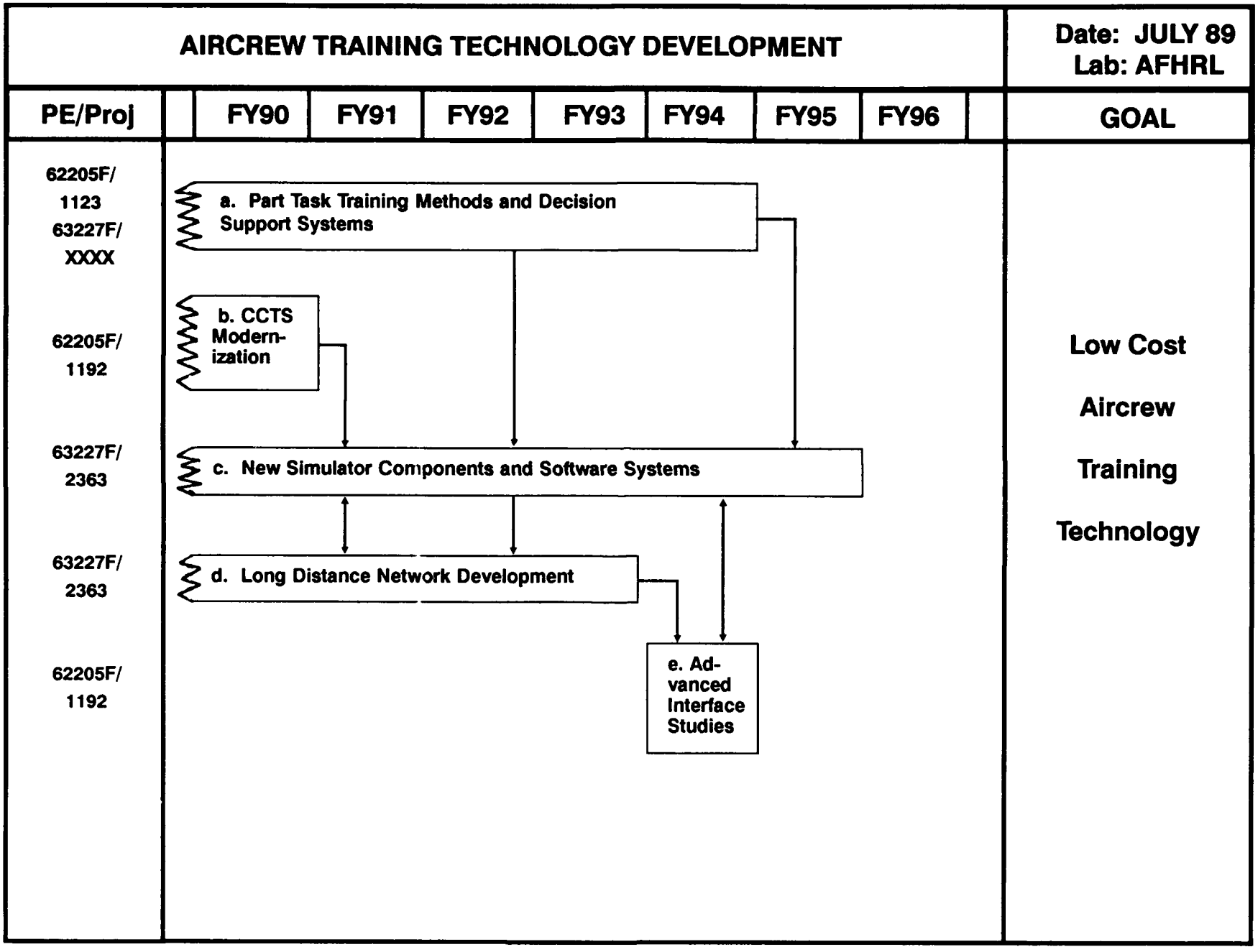


Fig 7. Training Technology Subthrust OT-2. Aircrew Training Technology Development

a. Part-Task Training Methods and Decision Support Systems. The practice of subdividing complex flight tasks into various parts is a logical way of presenting the student with a task that is, at the outset, not too difficult to master. By this rationale, the larger or more difficult the task, the greater the advantage of part-task training. The critical requirement in designing part-task training is to select effective strategies for partitioning a task for part practice, then later to reintegrate the parts into the whole task. AFHRL R&D has focused upon task partitioning strategies (e.g., simplification, fractionization, segmentation) in designing the PTT system; the need for and importance of performance measurement systems as opposed to simple practice without performance measurement; and ways in which computer-assisted instruction techniques can be used to facilitate the part-task training process. During FY 90, OT will validate the various methods of partitioning tasks that have already been developed and demonstrate PTT devices in different major command (MAJCOM) settings. A decision support system for use by PTT system designers will be developed in FY 92, and the information on the use of computer-assisted instruction techniques will be pulled together and integrated into a users guide for Part-Task Training devices in FY 93. Following this (in FY 94), some advanced work will be conducted on the networking of interactive, low-cost, multi-person aircrew training devices.

AFHRL R&D has focused upon task partitioning strategies in designing the part-task training system.

b. Combat Crew Training School (CCTS) Modernization. A thorough review and analysis of Air Force B-52 and KC-135 training requirements will be conducted in order to prepare a detailed functional design specification for the training conducted at the B-52/KC-135 CCTS. The modernized program will provide for the effective use of existing training media and the optimal mix of academics, ground trainer, and flight instruction required to produce combat-ready aircrews. Included within the total training system design will be the definition of computer and maintenance support, instructional delivery, performance evaluation, and total training system management.

c. New Simulator Components and Software Systems. New simulator components and software systems to be investigated are: (1) a thermal model to assign "gray" shades to portions of an infrared computer-generated image (based upon environmental conditions) so that forward-looking infrared (FLIR) sensors can be simulated (FY 90); (2) a VME-based modular computer software architecture that will enable re-hosting of current simulation software systems using inexpensive microprocessors (FY 91); (3) a helmet-mounted liquid crystal display (LCD) that will provide inexpensive visual display combat simulation applications (FY 91); (4) a high-brightness, high-resolution wraparound visual display, the dodecadome, which makes use of inexpensive cathode-ray tube (CRT) projectors (FY 92); (5) field-deployable, microprocessor-based image generators (FY 94); (6) an eye-tracked variable acuity visual display system that approaches the resolution of the human visual system (FY 95).

d. Long Distance Network Development. The local area network system will be expanded into a long distance network in FY 92-93, as the state-of

the-art is expected to permit that kind of advance at that time. This will permit pilot trainees in one part of the world (e.g., the Red Flag training staff at Nellis AFB) to engage in combat with pilots in another part of the world (e.g., United States Air Forces in Europe [USAFE]) without leaving their home base.

e. Advanced Interface Studies. During FY 94, a number of advanced interface studies will be conducted with the objective of expanding the scope of the Aircrew Combat Mission Enhancement (ACME) training system to include Navy and Army forces. Work will also be conducted to evaluate the use of these expanded simulation programs to evaluate war-gaming options and to study the conditions under which the development of creative solutions to combat problems is facilitated by the use of training simulator devices.

3. Aircrew Combat Mission Enhancement (ACME). ACME is an advanced development project whose objective is the enhancement of combat mission readiness through advances in flight simulation technology. The primary thrust of the program will be to investigate issues of training effectiveness concerning the value of multi-ship combat simulation. Two principal products will be developed and delivered under ACME to support the training effectiveness research program: (1) a situational awareness training research facility for conducting multi-ship force-on-force combat simulation R&D; and (2) a mission rehearsal training research capability that will permit determination of terrain/target familiarization and attack coordination/timing requirements. Both capabilities will be used in support of a continuing technology base research program attempting to provide answers to the critical issues of: how to measure and assess the combat readiness of our aircrews; what can be done to facilitate the acquisition and maintenance of an enhanced state of readiness; how to structure training to systematically address the problems of situational awareness and mission rehearsal; and how to match a specific training requirement to the most cost-effective level of device fidelity. The bottom line is, "How can we best prepare our aircrews to meet the demands of a wartime environment using limited peacetime resources?"

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A roadmap for the plans in this area is at Figure 8. Important areas of work are:

a. Training Effectiveness Evaluations. A vigorous program of behavioral research will address training effectiveness issues associated with multi-ship combat training simulation. Specifically, experiments will be conducted to quantify: (1) the effectiveness of training; (2) the military value of such training, by considering both costs and measured increases in operational effectiveness; and (3) the tradeoffs between centralized and distributed training resources (i.e., training centers versus squadron training). Up to five critical experiments will be conducted for four primary mission areas: Air-to-air, interdiction, close air support, and mission rehearsal. In accomplishing these studies, facilities to be used include the ACME multi-ship test-bed R&D facility, as well as simulation facilities available within industry. For the interdiction mission, the following five experiments will be accomplished using the in-house ACME test-bed: (1) utility evaluation of the perceived effectiveness of the simulation in FY 91-92; (2) within-simulator learning and transfer in FY 92-94; (3) between-simulator transfer effects using low-cost reconfigurable pilot stations in FY 91-94; (4) real-world transfer of training in FY 94-95; and (5) unit effectiveness evaluations in FY 95-99. Results from these critical experiments will be used to quantify the benefits gained from ground-based combat simulation training.

b. F-15 Advanced Air Combat Simulation. In FY 88, AFHRL initiated an ACME proof-of-concept demonstration using simulation facilities available within industry. In a joint effort with the Tactical Air Command (TAC), a simulation training program was created using the engineering simulation facility at the McDonnell Douglas Aircraft Corporation in St. Louis, MO. Training scenarios focused on the various air-to-air missions including sweep, combat air patrol, and escort. User acceptance data, as well

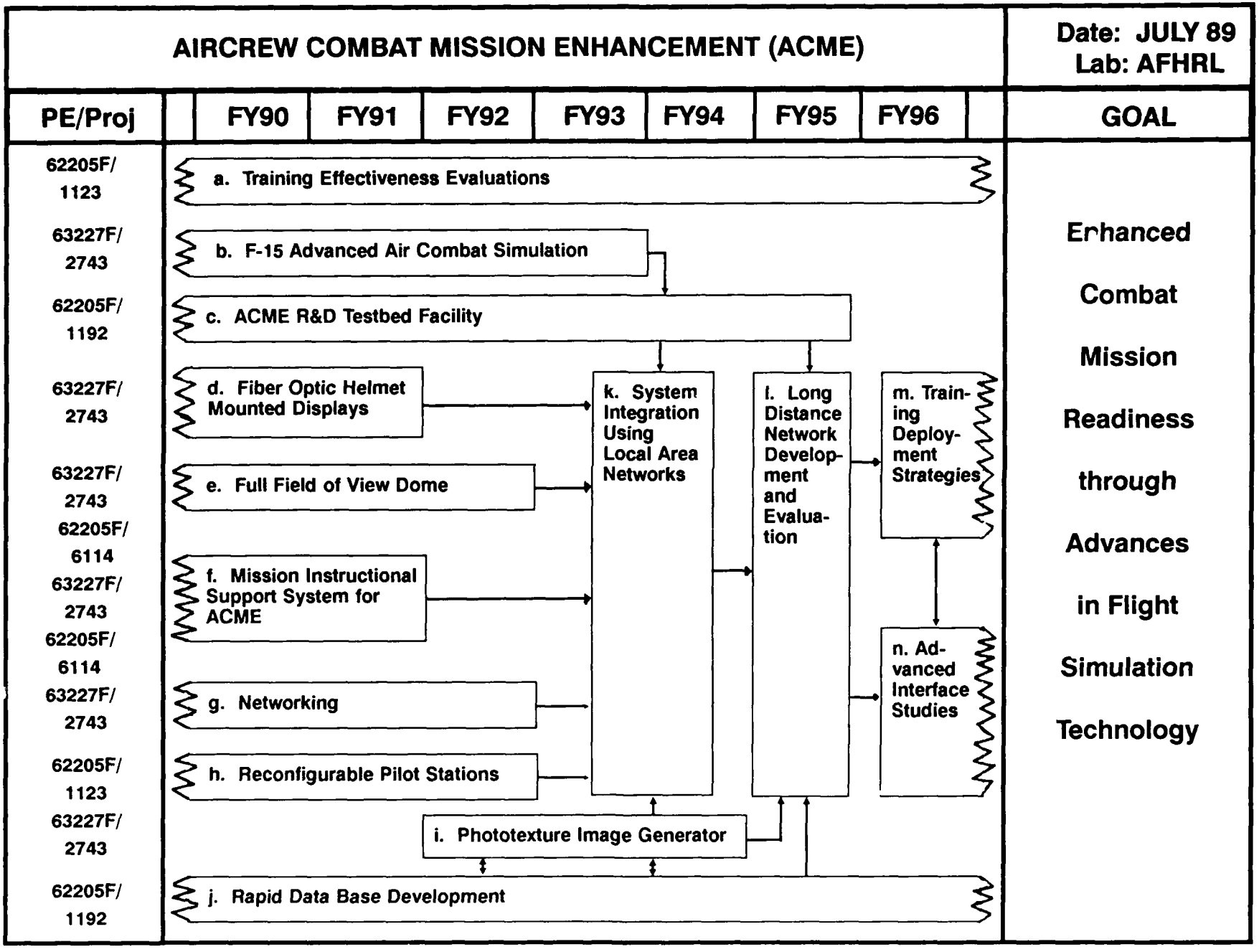
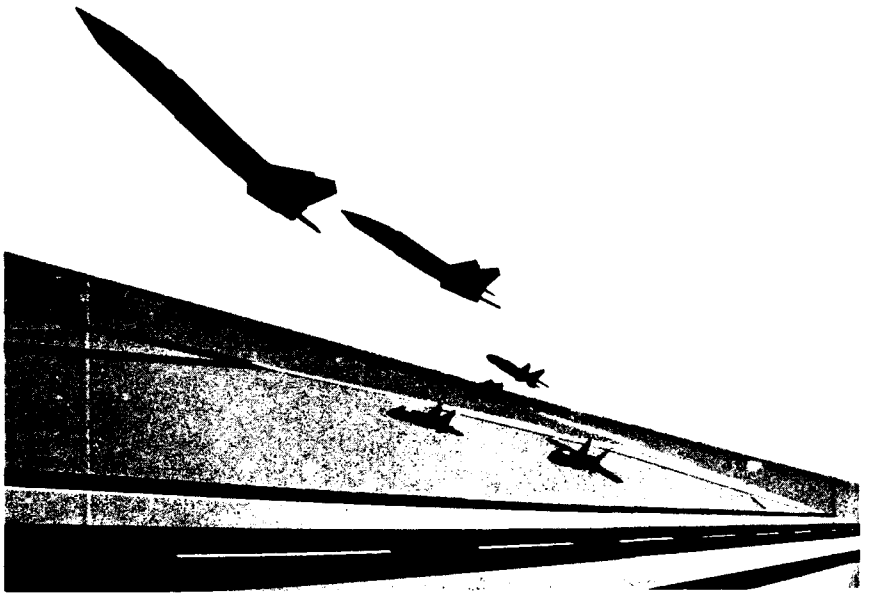


Fig 8. Training Technology Subthrust OT-3. Aircrew Combat Mission Enhancement (ACME)



AFHRL has enhanced training effectiveness using multiple moving models.

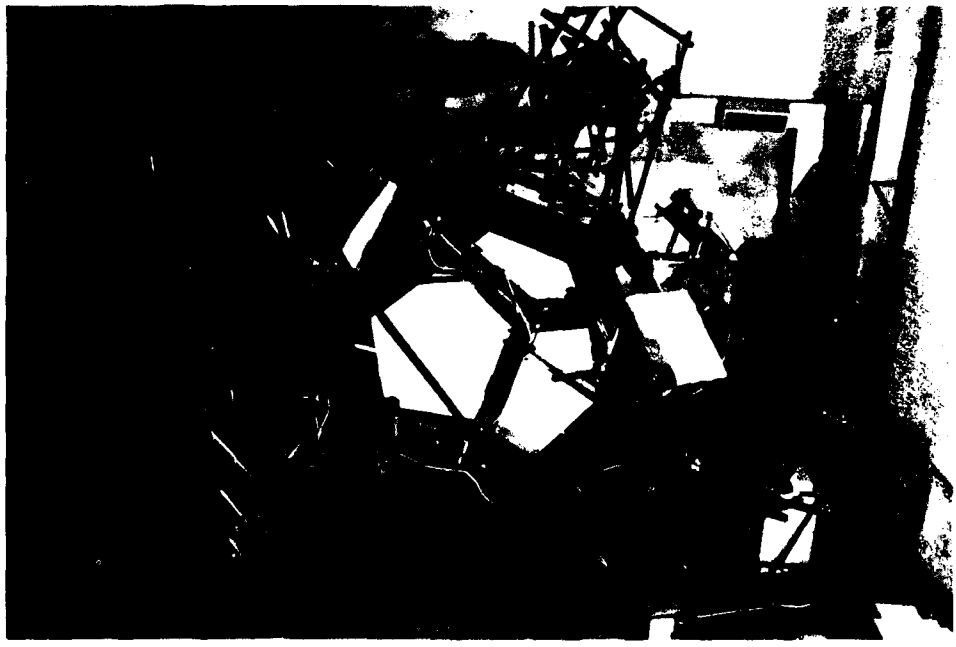
as engagement outcome information, were gathered throughout the program. The results indicate that both pilots and air weapons controllers considered the training received to be quite valuable. The outcome data indicate improvements in performance as a function of such training. Beginning in FY 90, this program will transition to TAC. AFHRL plans to continue work in the air-to-air mission area at the St. Louis facility, with the following training effectiveness experiments scheduled: (1) within-simulator learning and transfer in FY 90-91; (2) between-simulator transfer effects using low-cost reconfigurable pilot stations in FY 90-92; and (3) real-world transfer of training in FY 92-93.

c. ACME R&D Test-Bed Facility. The ACME R&D test-bed facility will produce an interactive force-on-force simulation of a wartime environment. To accomplish this, a tactical multi-ship simulation focusing on the F-16 aircraft will be developed at Williams AFB. The network will eventually consist of: four F-16 cockpits with state-of-the-art out-of-the-cockpit visual systems consisting of two full-field-of-view domes and two fiber optic helmet-mounted displays; four F-16 player stations with full functioning avionics but limited visual capabilities; two tactical air control stations for Red and Blue forces; an instructional support system for scenario preparation, on-line monitoring, and post-mission debriefing; and a modular threat environment simulation system. These components will be networked together using the approach developed by Defense Avanced Research Projects Agenc (DARPA) in the Army's SIMNET facility. The simulation complex will also have the capability for long-haul networking to other simulation facilities. Candidate locations and facilities include the VTRS facility at the Naval Training Systems Center (NTSC) in Orlando, the new Simulator Complexity Test-Bed Facility being developed by ARI at Ft Rucker, and the SIMNET complex at Ft Knox. Completion of this situational awareness training research complex is expected by FY 92. The addition of a photo-texture image generation capability will produce a system capable of pre-strike mission planning and rehearsal. It will enable crews to practice waypoint/target area familiarization, as well as attack coordination and timing. Technology requirements include the development of a multispectral image generation capable of producing photographic-quality visual imagery and generating data bases rapidly. Expected completion date of the mission rehearsal capability is FY 95. The individual components within this facility are described in subsequent sections.

d. Fiber Optic Helmet-Mounted Displays. The objective of the Fiber Optic Helmet-Mounted Display (FOHMD) program is to develop a cost-effective visual display suitable for both air-to-air and air-to-ground tactical simulation. This objective is achieved by using high-brightness projectors to supply imagery which is optically combined to provide a high-resolution inset within a low-resolution background. This imagery is injected into lightweight, flexible fiber optic bundles for delivery to the pilot's eyes via helmet-mounted infinity display optics. By tracking head and eye position, the insets can be servoed to the point of gaze, thus providing a resolution and viewing space nearly

The objective of the FOHMD is to develop a cost-effective visual display for both air-to-air and air-to-ground tactical simulation.

equal to that required by the human visual system. This program is a 50/50 cost-sharing program with the Canadian government. Retrofit of the system with a fully functioning eyetracker will be completed in FY 90. Enhancements to the fiber bundles will be completed in FY 91.



AFHRL R&D has developed a new low-cost, high-resolution, wide field-of-view display.

e. Full-Field-of-View Dome. The goal of this program is to develop a display system capable of providing imagery over the entire field of view as seen from the cockpit of an F-16 aircraft. The system will provide high-resolution imagery that permits both air-to-air and air-to-ground training. The effort is a joint AFHRL/OT and Aeronautical Sytems Division (ASD/YW) program in which funding is shared equally. The 24-foot dome display system, which is being developed by McDonnell Douglas Aircraft, will include a high-resolution, 40-degree linear inset displayed against a low-resolution background. The system will be headtracked, with the provision for adding eyetracking as that technology becomes available. Upon delivery, the system will be interfaced with the Advanced Visual Technology System (AVTS) at AFHRL and will be used for visual training effectiveness work as well as being a primary high-end component of the ACME R&D test-bed facility. Delivery and integration will be completed in FY 90. Training-effectiveness evaluations will be accomplished in FY 90-92.

The Full-Field-of-View Dome will provide a view as seen from the cockpit of an F-16 aircraft.

f. Multi-Ship Instructional Support System for ACME (MISS ACME). This is a jointly funded project with ASD/YW for the development of an instructional support system for the ACME SAT facility. Its goals are (1) to satisfy the ACME SAT requirements for a control, measurement, mission planning, briefing, and debriefing system; and (2) to satisfy generic IOS concept requirements for the development and validation of modular, transportable software for multi-ship instructional support systems. A three-phased program is planned, leading to the delivery of the system and integration with the ACME network in FY 91. A transportability demonstration is also planned for validation of the generic IOS concept.

g. Networking. This tri-Service project will extend the Army's SIMNET protocol to meet the communication requirements of flight simulators and will specify the protocol as a network standard. The hardware and software components necessary to implement the standard (both local and long-haul) will then be designed and developed. Each flight simulator that will use the network will be provided the design of these components, along with engineering support to aid their integration. The project will also evaluate the performance of the network, estimate the amount of communication that can be supported, and determine the number of interactive flight simulators that can operate reliably while providing effective training. Facilities to be included within this network include the ACME SAT facility at Williams AFB, the VTRS flight simulation complex at Orlando, the AH-64 research simulation complex at Ft Rucker, and several SIMNET modules located at Orlando. The local network to link components of the ACME R&D test-bed facility will be completed in FY 91. The long distance network with the other facilities will be completed in FY 92.

h. Reconfigurable Pilot Stations. This effort will produce a low-cost network of reconfigurable pilot stations that can be used as either (1) components of the ACME R&D test-bed facility or (2) stand-alone devices that can be deployed for squadron-level training. These reconfigurable pilot stations must enable the aircrew to perform the critical combat-related tasks that are necessary components of realis-

tic mission scenarios. The starting point for their development is the current configuration of the F-16 Air Intercept Trainers. Additional capabilities necessary to support ACME requirements will be identified and incorporated within the systems. These pilot stations will eventually be retrofitted with low-cost visual image generation and display systems. The stations will use a common network protocol and may be operated independently of the ACME R&D facility network, thus providing certain part-task training opportunities. These stations, in an F-16 configuration, will be completed in FY 91. Software to support both F-15 and A-10 simulation will be completed in FY 92.

i. Photo-Texture Image Generator. To provide a mission rehearsal capability within the ACME R&D test-bed facility, a photo-texture image generator (IG) will be acquired beginning in FY 92, with delivery expected in FY 94. Given the rapid advances in visual image generation technology that are now occurring, it is likely that such a capability can be acquired as an off-the-shelf system. The photo-texture IG will generate high-resolution visual imagery from photographic sources, thus enabling far greater scene detail than is now available with current systems. The system must also be capable of generating correlated radar and infrared imagery. The acquisition of such a system is considered an essential component of the training effectiveness research program that addresses mission rehearsal.

j. Rapid Data Base Development. The most important requirement for mission rehearsal is likely to be waypoint and target familiarization. This, in turn, requires the development of highly detailed and accurate digital data bases for use by a multispectral image generator. Moreover, it is essential that these data bases be constructed in a relatively short period of time (e.g., 24-72 hours). The capability to develop such high-resolution data bases with at-

AFHRL is researching data base development to provide detailed digital information necessary for image generation.

tributes necessary for infrared, radar, and visual simulation in such a short period is well beyond the current state of the art. AFHRL is maintaining a close technology watch on key programs including ASD's Project 2851, which is attempting to develop a DOD standard data base and common transformation software that can be used for simulator training devices requiring the use of digital cartographic data. Under this effort, there is also a project being funded by the U.S. Army for a Rapidly Reconfigurable Data Base that is to be completed in FY 90. The results of these technology efforts will be incorporated into the ACME R&D test-bed facility as they become available.

k. Systems Integration Using Local Area Networks. During FY 93-94, a number of ACME components will be integrated, and the best approaches will be selected. Evaluative studies will be initiated on integrated combat simulators that are capable of providing situational awareness training to a small group of pilots at the same time, using a local area network to provide some of the interactions between pilots, their controllers, opponents, and simulated friendly forces.

l. Long Distance Network Development and Evaluation. The local area network system will be expanded into a long distance network in FY 95, since the state of the art is expected to permit that kind of advance at that time. This will permit pilot trainees in one part of the world (e.g., USAFE) to challenge experts in another part of the world (e.g., the Red Flag training staff at Nellis AFB) without leaving their home base.

m. Training Deployment Strategies. During FY 96, ways of deploying the ACME training systems will be examined from a cost-effectiveness point of view. Simplification and weight reduction options will be considered and evaluated.

n. Advanced Interface Studies. During FY 96, a number of advanced interface studies will be conducted with the objective of expanding the scope of the ACME training system to include Navy and Army forces. Work will also be conducted to evaluate the use of these expanded simulation programs to evaluate wargaming options and to study the conditions under which the development of creative solutions to combat problems is facilitated by the use of simulator training devices.

4. New Concepts in Aircrew Training Systems. Although they have not yet been organized into thrusts, new concepts in aircrew training systems are being developed at the Operations Training Division as a result of exploratory and advanced development studies.

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One important probe study proposed is to establish a knowledge base of pilot combat skills for use in aircrew training. It will include the areas of air-to-air, air-to-ground, and threat evasion techniques. Artificial Intelligence (AI) will be used to break up tasks and develop part-task trainers that will use AI to optimize instruction and model performance. Information on tactics and execution will then be incorporated into expert knowledge data bases for use in full mission simulator training exercises. A generalized AI model for use in part-task trainers will be developed in FY 90. Expert systems for use in full mission simulators will be demonstrated in FY 92.

5. Aircrew Training Research Support Contracts. All of the aircrew training efforts are supported by two research support contracts. One contract provides operations, maintenance and programming support for Digital Image Generators (DIGs), display systems, cockpits, and consoles. These contracts are competed every 5 years, with the next round of competition scheduled in FY 92 for a contract start in FY 93. Another research support contract provides quick-response technical and programming support for in-house and contractor R&D efforts. This contract is normally competed every 3 years. Rounds of competition during the FY 90-95 timeframe are tentatively scheduled for FY 92 and FY 95.

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6. Command and Control (C^2) Systems Analysis and Training. The evolution of the C^2 function in the Air Force is increasing both the challenge of training

C^2 teams and the payoff of such training. Future C^2 systems will involve a network of interdependent nodes; if some nodes are destroyed during combat, other nodes will have to assume their functions. So, the Air Force will have to train its C^2 teams to perform a wide range of functions. In addition, the complexity of battle management will increase. With this increase come additional requirements to provide both realistic combat training opportunities and system design guidance.

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Figure 9 is a subthrust roadmap for AFHRL's planned C^2 program.

a. Training for Decision Making. This continuing effort involves gaining the decision-making knowledge of expert battle managers through knowledge engineering and using it to construct a computer-based learning setting for training higher-level decision-making skills. A prototype training system for the Pacific Air Forces (PACAF) will be completed in FY 90.

b. Part-Task Trainers for High Performance Skills. AFHRL is developing a new generation of part-task trainers based on an application of automated information processing principles to high performance C^2 skills. AFHRL is accomplishing the required research on skill retention, workload reduction, and transfer in FY 89-90. A prototype part-task trainer for C^2 skills will be built in FY 90 and evaluated during FY 91.

c. Training for Functionally Distributed Systems. This R&D uses wartime simulations like TAC THUNDER to assess the decision making of individuals and teams working in functionally distributed systems. AFHRL will investigate team effectiveness and decision making under proposed C^2 configurations. Later, this effort will be linked to the Aircrew Combat Mission Enhancement (ACME) program discussed above. Linking the two efforts will allow emulation of an actual Control and Reporting Center (CRC). Facility modifications to support studies of networked battle management will be completed in FY 90. The initial link to ACME will occur in FY 90 and be evaluated during FY 91.

d. Training for Senior Battle Managers. Beginning in FY 93- 94, the Laboratory will bring together the work on part-task trainers on high performance skills and on training for functionally distributed systems to build a demonstration training system for higher-level battle managers.

AFHRL will build a demonstration training system for higher-level battle managers.

e. Training for Logistics C^2. Here the goal is to develop a system to provide knowledge-based training in decision making to logistics battle staffs. As now envisioned, this system will provide training at peacetime duty stations. It will give novices exposure to the complex decisions and variables associated with wartime logistics. Development of an expert knowledge base will be accomplished in FY 90 and a demonstration training system will be evaluated during FY 91-92.

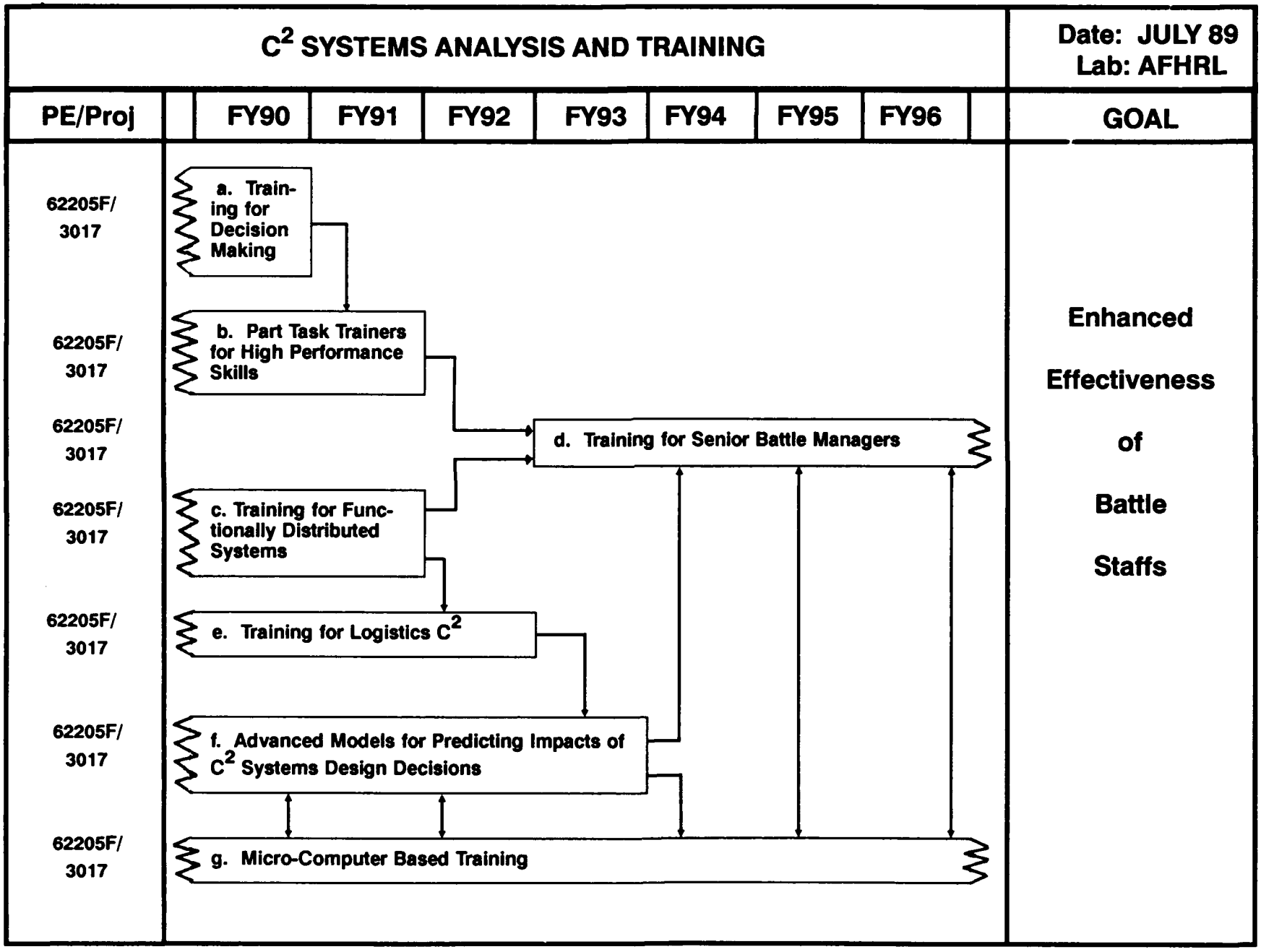

Fig 9. Training Technology Subthrust LR-4. C^2 Systems Analysis and Training

f. Advanced Models For Predicting Impacts of C^2 System Design Decisions. This effort will be initiated in FY 90 to expand and refine initial methods for assessing the impact of automation on the tactical C^2 systems developed and demonstrated in FY 89. These new tools will provide predictive models and systems emulations of a Tactical Air Control Center by FY 93. If feasibility studies planned for FY 91 are encouraging, this work will be moved into the 6.3 funded Simultaneous Engineering domain. There AFHRL will use it to develop design tools for predicting the "operability" of new weapons systems.

g. Microcomputer-Based Training. This activity integrates the technologies developed under the 6.2 program in training for battle management and focuses on training the Modular Control Equipment (MCE) teams. It will emphasize job familiarization, decision making using knowledge-based simulation, and team training. System requirements analysis will be completed in FY90.

The computerized management and delivery of training will increase the efficiency of Air Force technical training.

7. Technical Training Development and Delivery. The Air Force could have a technical training gap in the future. New weapon systems and new war-fighting tactics will increase both the number and the complexity of the tasks that airmen must master. But, training resources are unlikely to grow. The Air Force can avoid a technical training gap only if it uses its training resources more efficiently. The computerized management and delivery of training could increase the efficiency of Air Force technical training. So, AFHRL has made them the major focus of its technical training R&D program (see roadmap at Figure 10).

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Figure 10 summarizes how AFHRL plans to help make computerized training a more efficient and effective tool for the Air Force.

a. Computer-Based Training (CBT) Selection and Application. Should I select computer-based training (CBT) as the medium for this course? What factors should I consider in making that decision? If I do decide on CBT, how should I plan and execute a CBT program? This project addresses such training planning questions. It will explore, develop, and test principles that will guide the selection and application of CBT technologies in Air Force technical training. This effort will provide guidance for training managers concerning CBT course selection/conversion and CBT system selection. It will deal with cost/benefit analysis, CBT program planning, and risk assessment. The payoffs will include more efficient and effective CBT program planning and better use of resources through appropriate CBT applications.

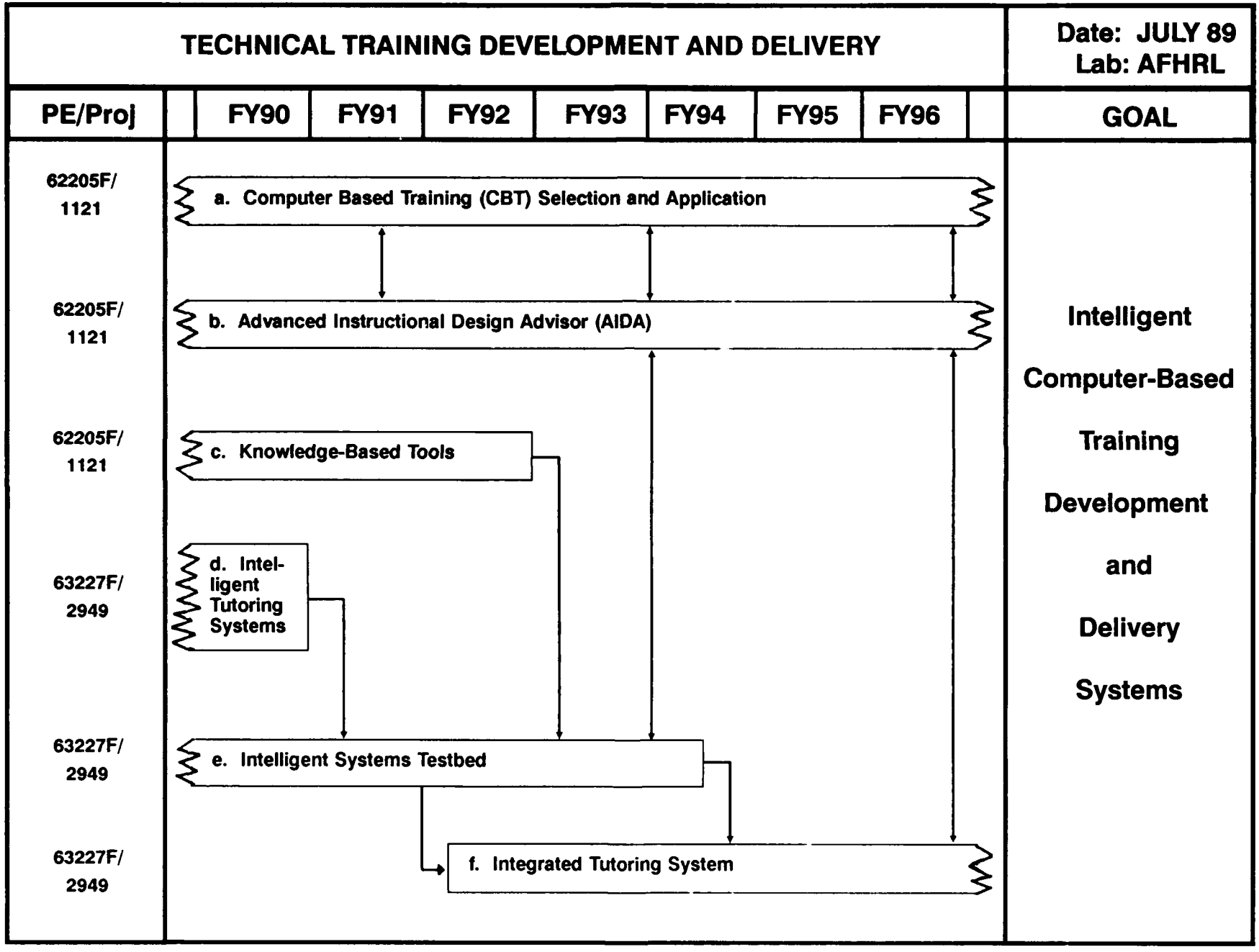


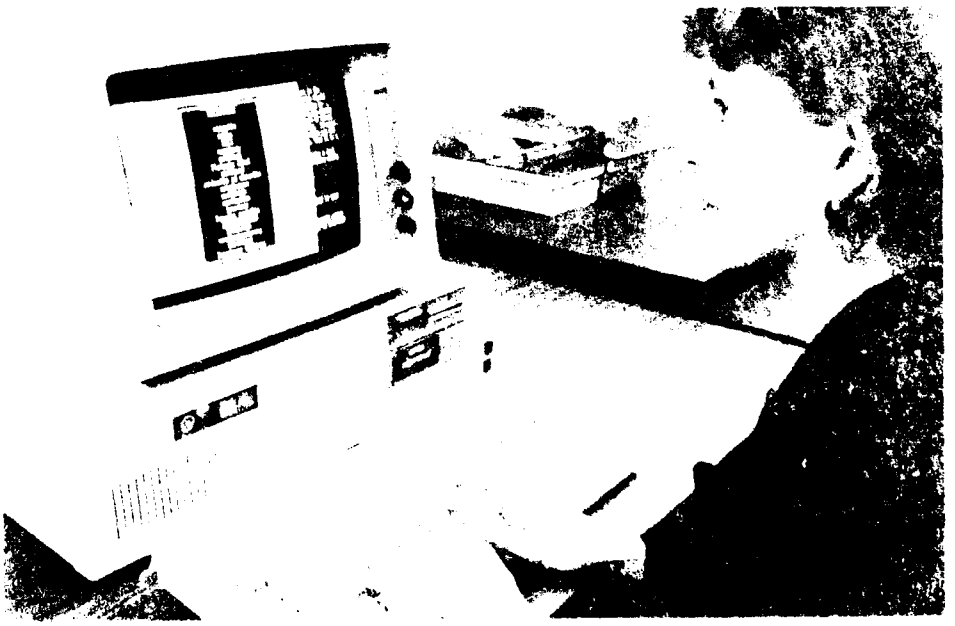
Fig 10. Training Technology Subthrust ID-1. Technical Training Development and Delivery

AFHRL's R&D will explore, develop, and test principles that will guide the selection and application of CBT technologies in Air Force technical training.

b. Advanced Instructional Design Advisor (AIDA). The increased demand for high quality training, coupled with the scarcity of instructional design expertise within the military, has resulted in a need to automate the instructional design process. Prior efforts to automate this process have met with limited success because learning problems and knowledge types have not been comprehensively addressed. This effort will develop a set of principles which could provide automated guidance for novice courseware developers. Initial products will be: (1) a theoretical framework and prescriptive instructional model, which will synthesize previous learning theory; and (2) courseware development specifications for effective instruction.

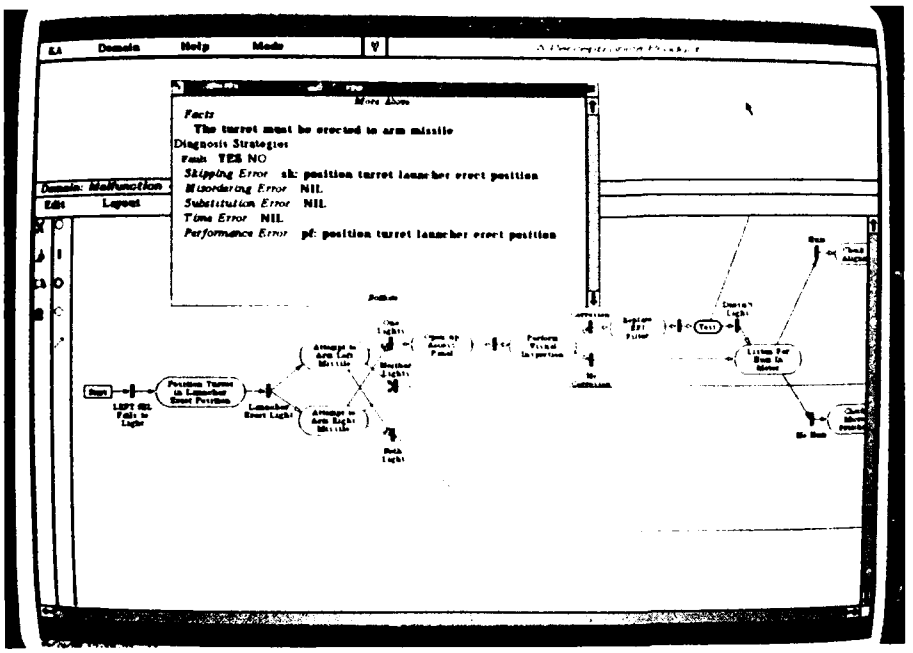
c. Knowledge-Based Tools. The building of the first intelligent tutoring system (ITS) has shown that drawing out expertise from experienced practitioners in a field is an expensive process. The costs of the so-called "knowledge engineering" process must be reduced if intelligent tutoring systems are to become widely used in the Air Force. This effort, which is sponsored jointly by the Army Research Institute, the Naval Training Systems Center, and AFHRL aims to bring down the costs of building ITSs. It will do so by developing software tools that will allow expert practitioners with minimal instructional design and computer programming skills to develop key parts of the ITS.

d. Intelligent Tutoring Systems. This effort will develop several ITSs for Air Force application to find out what kinds of instructional strategies and stu-



The building of the first intelligent tutoring system has shown that drawing out expertise from experienced practitioners is an expensive process.

dent interfaces are most effective. The Laboratory will also use the ITSs to find out what kinds of applications have the highest payoffs. An ITS for space operations will be completed in FY 91.



Knowledge acquisition is a joint-Service initiative to design and develop intelligent computer-assisted instructional tools and techniques.

e. Intelligent Systems Test-Bed. This work will deliver a proof-of-principle prototype system for rapid development of ITSs and empirical evaluation of instructional strategies for ITSs. Called the "Rapid Prototype ITS Development System (RAPIDS)", the system initially will be developed to run on a Xerox 1186. If the initial version is successful, AFHRL will develop a version that would run on a standard Air Force microcomputer. The activity will yield not only RAPIDS but also empirical information about the effectiveness of different instructional strategies for ITSs.

f. Integrated Tutoring System. The rapid development in ITS technology is being paralleled by the rapid emergence of interactive visual training technologies. Once ITS technology matures, it will be possible to link ITS technology with interactive training technologies to develop a multi-media ITS.

8. Technical Training Systems Design. The planning, implementation, and operation of systems for technical training involve many interactive decisions. They have implications for Air Force resources. Moreover, how well the decisions are made can have large impacts on the efficiency and effectiveness of the technical training systems.

Decision support systems consist of computerized job aids for decision makers. They can help training decision makers to reach better decisions more rapidly. Due to the fact that decision support systems can both improve the average quality of decisions and cut the costs of making them, they have a large potential for improving the efficiency and effectiveness of the Air Force's technical training systems. They offer opportunities to accomplish more with fewer resources.

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Figure 11 summarizes how AFHRL is planning to provide management tools that could increase the efficiency and effectiveness of technical training in the Air Force.

a. Job Aiding/Training. This effort will explore and develop methods to enhance the integration of training and aiding considerations in weapon system design practices. Now training and aiding are treated as independent methods to enhance human performance. Increased future demands on its personnel will prevent the Air Force from continuing to view these functions as independent. We know little about how job aiding and training technologies interact and how they should be interfaced to enhance human performance. Increased knowledge about the interactions and interfaces between job aiding and training will be a key product of this activity. In addition, this effort will use this knowledge to develop training technologies that best support advanced job aids like the Integrated Maintenance Information System (IMIS) in FY 92.

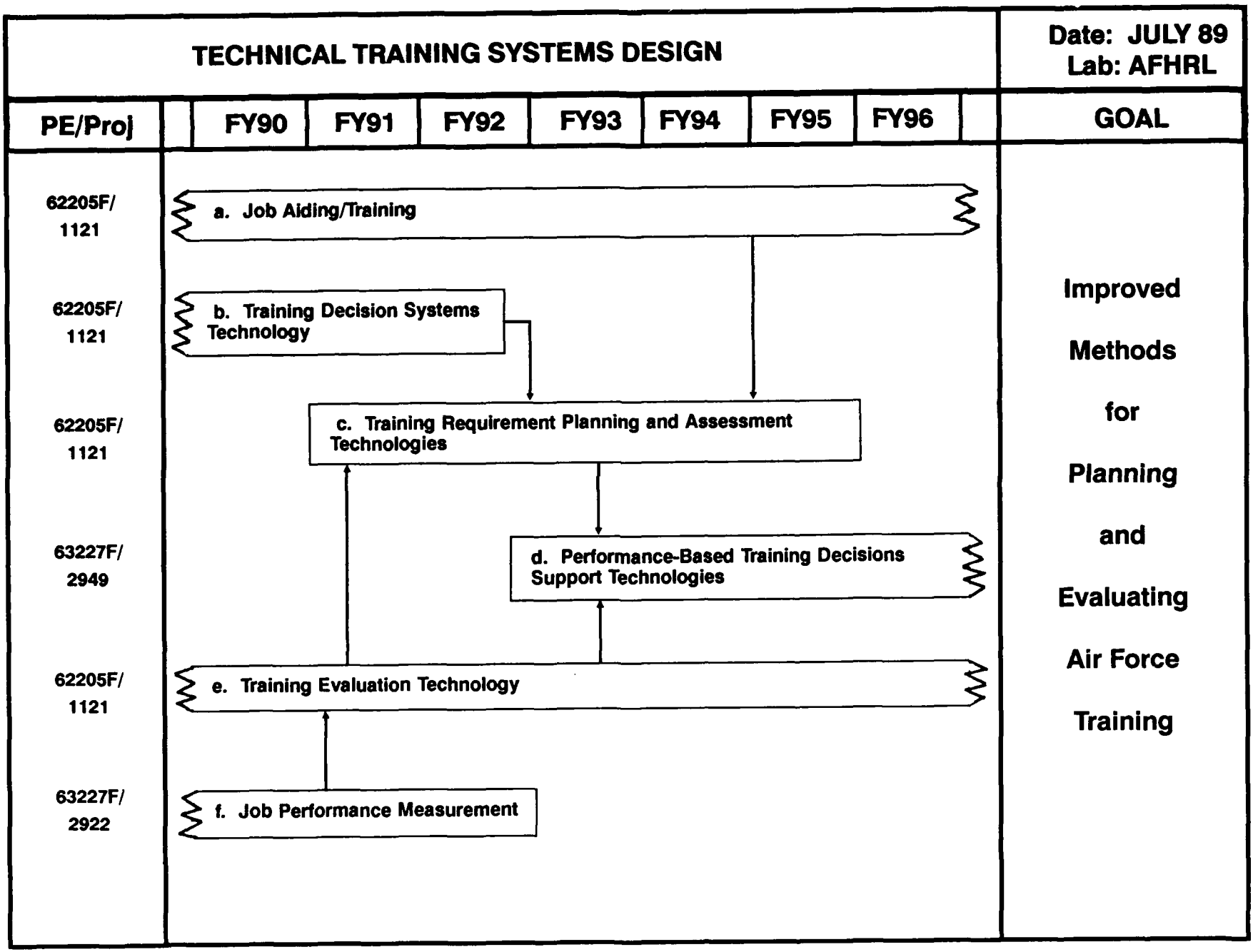


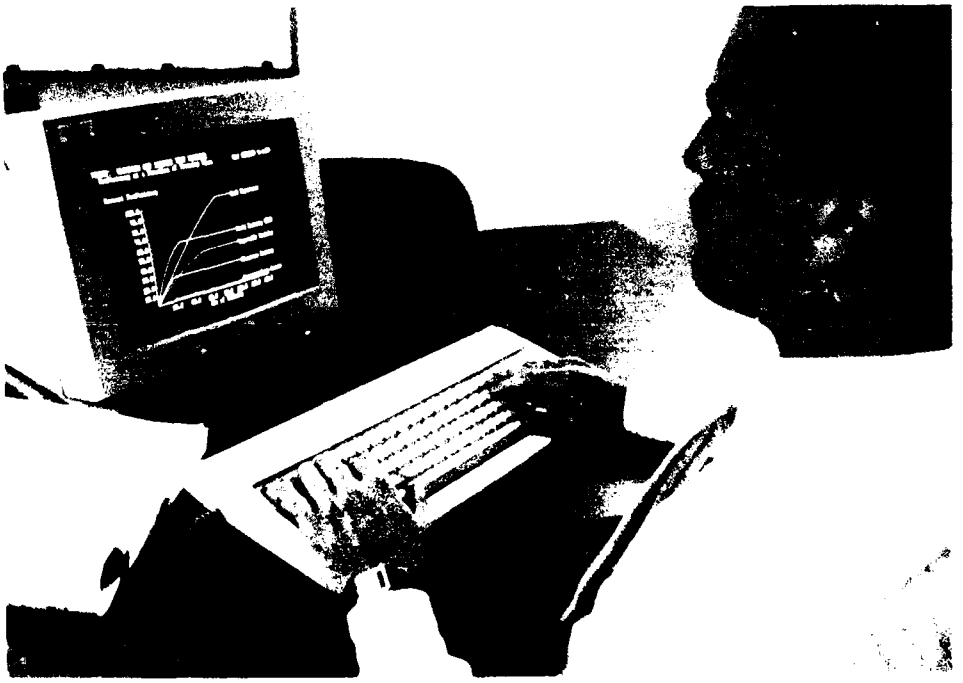
Fig 11. Training Technology Subthrust ID-2. Technical Training Systems Design

b. Training Decisions System Technology. The Training Decisions System (TDS) program aims to develop a more unified and integrated approach to macro-level training programming and planning. The TDS integrates training requirements, as well as manpower and cost considerations, into a single comprehensive model. The TDS uses information about the jobs performed by airmen, about personnel assignment flows, and about training capacities to identify the most cost-effective training option available. This follow-on research program will build upon earlier exploratory development work which resulted in a proof-of-concept, computer-based, decision support technology. TDS is capable of dealing with decisions about what tasks to train, where to train them, and when in enlisted careers to train them. The preliminary technology already has been used to address several Air Force planning issues; they included the impact of reduced TDY-to school funding, the impact of reduced Airman Basic Resident (ABR) technical school funding, and the resolution of resource capacity limitations for on-the-job training. The project is scheduled for completion in FY 92.

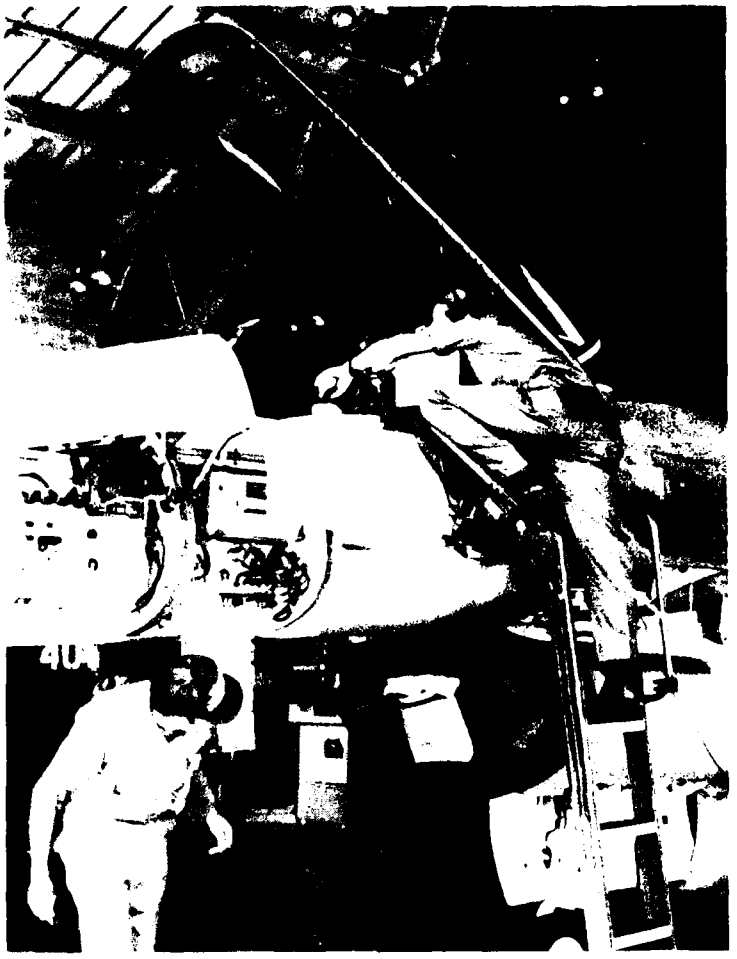
c. Training Requirements Planning and Assessment Technologies. This new project will integrate R&D technologies resulting from the Training Decisions System (TDS) and Job Performance Measurement (JPM) efforts. This effort will develop and evaluate the technologies related to training decisions modeling and training evaluation. It will provide the research and development needed to link these technologies. The project will provide Air Force training planners with the technologies that will allow them to plan training based on both cost and objective measures of job performance. This project aims to provide cost- and performance-based training planning technologies by FY 94.

d. Performance-Based Training Decisions Support Technologies. The object of this advanced development effort is to refine and extend performance-based training planning technologies developed with exploratory R&D funds. AFHRL will use these training planning technologies to analyze performance and cost issues based on alternative task identification and analysis techniques. These analyses will deal with multiple AFSs, weapon-system-specific AFSs, and projected AFSs for future weapon systems. This effort is scheduled to begin in FY 92.

e. Training Evaluation. This effort will use technologies developed through the job performance measurement project to explore ways of evaluating technical skills training. In particular, it will develop methods for measuring individual performance.



The TDS integrates training requirements, as well as manpower and cost considerations, into a single comprehensive model.



The Job Performance Measurement project will assess the ability of various measurement systems to identify the most cost-effective methods for collecting reliable job performance information.

Such measures will allow training managers/developers to assess accurately student achievement, transfer of knowledges and skills to the job setting, and the efficiency of training program design. Training managers/developers will be able to identify areas of potential over- or under-training. Preliminary development of the performance-based training evaluation system is expected to be completed by FY 94.

f. Job Performance Measurement (JPM). This project builds upon prior exploratory research efforts in which AFHRL developed multiple measures of individual performance and administered them to over 1,400 first-term airmen in eight enlisted specialties. The project now involves data analysis to determine the relationship between ASVAB scores and job performance capability. Additionally, the research will assess the ability of various measurement systems to identify the most cost-effective methods for collecting reliable job performance information. The Laboratory is exploring methodologies for setting classification standards based on a job performance criterion. Analysis will conclude in FY 92.

VI. PROGRAM RELATIONSHIPS

AFHRL is actively working to reduce unnecessary duplication of R&D efforts by participating in a tri-Service commanders meeting with the Army Research Institute (ARI) and the Navy Personnel Research and Development Center (NPRDC). Meetings are held quarterly, at which time programs are reviewed and joint initiatives are planned.

AFHRL also exchanges technology with allies through several programs. The Technical Cooperation Program (TTCP) provides for the exchange of information in the area of behavioral sciences with the United Kingdom, Canada, Australia, and New Zealand. AFHRL contributes to the North Atlantic Treaty Organization (NATO) by participating in the Psychological Fitness Study Group (AFHRL/MO), Manned Communications Interaction in Command and Control Panel (AFHRL/LR), and the Aircrew Selection Working Group (AFHRL/MO). AFHRL also has aircrew selection data exchange programs with the United Kingdom, Germany, and Australia. These programs will provide data needed to help validate tests developed at AFHRL.

With the expected decline of the service-eligible population in the 1990 timeframe, all the Armed Services are facing problems in attracting sufficient numbers of eligible personnel into military service. Ways of enhancing productivity of the workforce and retaining a quality career force are also high priority items. Based on the similarity of service issues and concerns, several tri-Service R&D working groups have been established to develop integrated and cooperative R&D programs to study these mutual problems. An example is the Joint Services Selection and Classification Working Group (sponsored by OASD (FM&P)-AP) and its associated Technical Task Group. These two working groups plan a comprehensive program for the development and validation of enlisted operational and high school testing programs. Systematic technical coordination is attained through group planning sessions and the exchange of contract and in-house R&D proposals. A cooperative service project to plan, develop, and implement an adaptive testing program is currently being pursued through membership on the Computerized Adaptive Testing Interservice Coordinating Committee (CATICC). Finally, an inter-Service R&D working group was established to focus on the development of on-the-job performance measures to be used in the validation of service selection programs.

AFHRL maintains active technical coordination with the Wright Research and Development Center (WRDC), Logistics Management Center (LMC), Aeronautical Systems Division (ASD), Armstrong Aerospace Medical Research Laboratory (AAMRL), Acquisition Logistics Division (ALD), and Rome Air Development Center (RADC). Reliability, Availability and Maintainability in Computer Aided Design (RAMCAD), Aircraft Battle Damage Repair, and Simultaneous Engineering are major projects AFHRL is jointly working with WRDC. Participants with AFHRL in the development of RAMCAD include other Air Force agencies (WRDC, RADC, and ASD System Program Offices [SPOs]). Other participants in RAMCAD R&D include the Naval Ocean Systems Center, the Fort Belvoir RD&E Center, and the Picatinny Arsenal through the Joint Logistics Commanders' RAMCAD working group. AFHRL is working with the David Taylor Naval Ship R&D Center on a DOD Standard for digital data. The human model in computer-aided design is a joint project between AFHRL and AAMRL. AFHRL personnel are members of the Joint Policy Coordinating Group for Logistics Research, Test, and Evaluation plus several joint-Service subgroups such as the RAMCAD panel. Close coordination is being maintained with agencies that will use the products developed by AFHRL R&D. A formal Memorandum of Agreement between ALD and AFHRL has been signed to promote orderly transitions of R&D products. As part of the agreement, an ALD officer is collocated at the Logistics and Human Factors Division (AFHRL/LR) to assist in the transitioning process.

Team Training Systems research is also coordinated with many agencies. Close liaison is maintained with elements of the Tactical Air Command, including support of Blue Flag exercises and the Joint Warfare Center. Systematic technical coordination is maintained with the Army and Navy through international programs such as The Technical Cooperation Program (TTCP). Active interface is maintained with AAMRL's work on console design and man-machine interfaces. Work achieving a comprehensive training capability for tactical command and control teams is coordinated with RADC, Electronic Systems Division, 4441st Tactical Training Group (Blue Flag), Air Ground Operations School, Air University, PACAF, USAFE, Ninth Air

Force. Twelfth Air Force, HQ AFSC, Air Staff, and selected Army and Navy organizations. Research on human information processing is conducted jointly with RADC. AFHRL's program is unique in its emphasis on training and technology for battle staff members and commanders.

AFHRL cooperation with NAVAIR and the Naval Training Systems Center (NTSC) led to the development of a Universal Threat System for Simulators (UTSS) concept to address common Air Force/Navy problems in threat/electric warfare (EW) subsystems development, acquisition, validation, and maintenance. The UTSS project will develop a standard data base of threat and electronic warfare models for real-time flight simulation applications.

A tri-Service effort in networking technology supports the ACME program. A simulator network standards working group has been established, consisting of representatives of industrial firms as well as representatives from AFHRL, NTSC, PM-TRADE, ARI, and DARPA. One of its objectives is to help accomplish interactive flight simulation. The Army protocol for SIMNET will be extended to meet the communication requirements of high-performance flight simulators. The payoff will be a standard communication network that all services can use to accomplish multi-force combat simulation.

Continuous technical exchange and coordination are also maintained in methodologies to support training system development, initial skills training, and on-the-job training (OJT). Liaison is maintained with pertinent industrial and educational programs. AFHRL is working with the Navy, Army, and several academic centers to coordinate Air Force AI program. One project (now complete) jointly sponsored by the Naval Training Systems Center (NTSC), ARI, and AFHRL was to develop a student diagnostic model along with knowledge acquisition tools and authoring aids for applying the model to training domains. As a result of this tri-service effect, AFHRL is increasing its efforts concerned with computer assisted knowledge engineering tools and techniques.

The Canadian and United States Governments are operating under a 50/50 cost-sharing agreement to develop a fiber optic helmet-mounted display (FOHMD). The FOHMD offers an impressive advancement in display system technology with significant increases in brightness and resolution at a substantial cost savings over conventional dome and dodecahedron displays. The Navy (NTSC) is working on a competing design and both will be ready for evaluation in the FY 90 timeframe. AFHRL is also working with ARI and the DOD Training and Performance Data Center (TPDC) to develop expert systems for use by training system designers.

R&D to develop a pilot performance measurement system is being accomplished by the Air Force, the Navy, the National Aeronautics and Space Administration, the University of Illinois, and the Royal Air Force. In addition, the Army has several related research projects in the area of combat simulation, including work on a low-level sponsor target identification system for attack helicopters.

Both the Army and the Navy have ongoing research in simulator effectiveness and are working jointly on the development of microprocessor-based part-task trainers with advanced interactive display capabilities. A tri-Service effort is also underway to develop standard data base formats for visual CIG systems (Project 2851, ASD/YWB). Continuous coordination is maintained with the Defense Mapping Agency on terrain presentation for low-level navigation and air-to-ground simulation.

Every year, AFHRL actively participates in the review and evaluation of the Independent Research and Development (IR&D) programs of industry. The scope of AFHRL's activities is illustrated by the actions that took place during the past year. AFHRL reviewed 54 company IR&D technical plans and found 206 projects (out of 265) relevant to Laboratory programs. The total company funds invested in these 206 projects was impressive--$86.7M. This is an increase from FY 88, when AFHRL reviewed 184 IR&D projects with a total company investment value of $62.8M.

Table 1. Investment Areas Supported by IR&D Efforts.

Investment Area	Cost	Percent
Aircrew training and simulation devices	$30.5M	35.2
Information and computational sciences	$20.5M	23.6
Technical training and artificial intelligence	$18.6M	21.5
Logistics and C^2 Systgems	$17.0M	19.6
Manpower and personnel systems	$0.1M	0.1
Total	$86.7M	100.0

The larger investments at the top of the list reflect the cost of expensive computer, simulation, and information systems needed to conduct the IR&D. The lowest investment area (manpower and personnel) reflects another reality of the marketplace. There is not much of a market outside the military for large-scale manpower and personnel systems of the type used by the Air Force.

VII. ACCOMPLISHMENTS

Recent AFHRL accomplishments are summarized below by Technical Area.

Manpower and Force Management

1. Prototype Job Tutor. This effort resulted in a successful and unprecedented field test of an intelligent tutoring system for F-15 avionics troubleshooting for one AFSC. Results support claims that a cognitive theory-based training system is effective in teaching complex cognitive skills (i.e., troubleshooting), that experience can be accelerated (20 hours of training boosted experience levels by as much as 3.5 years), and that a computer-based instructional approach is effective for avionics troubleshooting.

PLANNED USERS: HQ TAC/LGQ, HQ AFCC/LGM, ATC Tech Training Centers, USAFOMC.

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2. Transitioning of Methodology for Generating Efficiency and Effectiveness Measures (MGEEM). The MGEEM is a multi-step productivity measurement and enhancement procedure. It is designed to bring the managers and workers of an organization to consensus about the principal intended accomplishments of the organization called "Key Result Areas (KRAs)," and means of measuring each KRA, called "indicators." Once the indicators are developed, MGEEM then graphically links them to levels of effectiveness on specifically designed charts. Multiple indicators and units can be aggregated upward to derive higher-level organizational productivity measures. Data to support the indicators come from existing management information and reporting systems. Feedback to employees and supervisors can improve productivity and ensure that the Total Quality Management philosophy of continuous process improvement is an integral part of any organization. The MGEEM is being transitioned to the Air Force Management Engineering Agency (AFMEA) to support implementation of AFR 25-5, Air Force Management Engineering Program.

PLANNED USERS: AFMEA, ESC, AFOSR, AFLC, Navy.

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3. ASVAB Forms 15, 16, and 17. The Armed Services Vocational Aptitude Battery (ASVAB) is the primary enlisted selection and classification test for the United States Armed Services. New versions of the test must be developed on a regular basis. During FY 88, raw scores on ASVAB Forms 15, 16, and 17 were converted to operational scores for all services' selection and classification composites, using recruit data. These conversions will be evaluated using operational scores from applicant samples.

PLANNED USERS: HQ USAF/DPXOA, USMEPCOM.

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4. Armed Forces Qualification Test (AFQT). The Office of the Assistant Secretary of Defense (OASD) /FM&MP) requested a new test composite to replace the AFQT. Through the use of regression analyses and cross-tabulations, a new AFQT was developed by AFHRL/MO and accepted by the OASD for use in Armed Forces military qualification determinations.

PLANNED USERS: USAF/DPXOA, OASD (FM&MP), HQ USMEPCOM, CNO, HQ USA, HQ USMC.

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5. Selection and Classification Porta-BAT Data Base. The Portabat is a portable version of the Basic Aptitudes Test (BAT) battery. During FY 88, the test base for the Porta-BAT was expanded to 35 tests and 8 were validated against Undergraduate Pilot Training (UPT) pass/fail or the advanced Training Recommendation Board's Fighter/Attack/Reconnaissance (FAR) decision. Two models, one for selection and one for classification, were developed and will be used (by HSD/YA) to baseline an updated Porta-BAT model being acquired as part of a Pilot Selection and Classification System (PSACS). Plans are to expand the data base to include more operational unit test results. This system will be transitioned to ATC in 1991 and used to select and classify Air Force pilots for the Specialized Undergraduate Pilot Training program.

PLANNED USERS: HQ ATC, DCS Technical Training, Air National Guard, EURO-NATO Aircrew Selection Working Group.

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6. Learning Abilities Measurement Program (LAMP) Automated Testing System (LATS). The LATS is a software tool for the development of computer-administered experimental cognitive tests. LATS is written in Turbo Pascal and is implemented on the Zenith 248 microcomputer. LATS enables a psychologist to develop automated cognitive tests for the assessment of information processing abilities (processing speed, attention, memory, perception) and various cognitive skills. LATS tests are fully automated with respect to instructions, administration, data collection, and data reduction. At the heart of LATS is a "driver" program which understands a custom-made, high-level programming language. Because this language can describe complex sequences of stimulus presentation and stimulus contingencies, a wide variety of cognitive tests can and have been implemented. LATS will continue to evolve as the needs of LAMP stretch the limits of the system.

PLANNED USERS: Navy - NPRDC; AFHRL - to enhance technology base.

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7. Accession/Retention Model. Accession/retention research encompasses three different efforts to gain insight into the impact of economic factors on retention and accession. The results of a study on the retention of airmen in various Air Force specialties were used to develop the Air Force Reenlistment Analysis Package (AFRAP). AFRAP forecasts the impact of changes in bonuses, relative wages, and demographic factors, and predicts the effects these changes will have on the retention of airmen. Two other personnel market studies are the Joint Accession/Retention Study (which looks at how accession and retention are jointly determined), and the Civilian Availability Study (which estimates the number and skills of the civilians that the Air Force needs).

PLANNED USERS: HQ USAF/DPXA, OASD(FM&MP).

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Logistics Technology

1. Design Analysis Models (Crew Chief). Crew Chief is a computer-based anthropometric computer graphics design and analysis tool. It provides a data base containing information about Air Force technicians (male and female) for use in computer-aided methods to evaluate designs of weapon systems and equipment. The model is used to evaluate new weapon systems and equipment designs. Human-like positions/ movements such as standing, sitting, squatting, crawling, lifting, pulling, and tool usage are featured in the model. This effort encompasses both male and female technicians in both standard work clothes and the protective ensemble. The model can evaluate a proposed design in maintainability terms such as accessibility of equipment, tool usage within access areas, maintenance operations and task requirements, and load lifting requirements. It can be used by designers to do on-line analysis during early stages of the design

cycle. A prototype version of the model has been released to industry.

PLANNED USERS: ASD, Air Force Acquisition Logistics Division (AFALD), Industry; NASA has expressed interest in these tools for use in analysis of space operations

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2. Unified Data Base (UDB) for Acquisition Logistics. The UDB is a Logistics Support Analysis Record (LSAR) data base designed to improve the documentation and accessibility of acquisition logistics support data. UDB provides a data information and decision support system which enables logisticians and engineers to rapidly document, retrieve, and query a central data base on-line via a computer terminal. UDB conforms to MIL-STD-1388-2A and automates all the data elements of this standard through the addition of data elements supplemental to the military standard. The system may also be used to automate common acquisition data items. The UDB has been transitioned to AFALD.

PLANNED USERS: AFALD, Navy.

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3. Content Data Model (CDM). The CDM provides structure to the rapidly developing world of digital data bases and electronic information systems. It describes in one cohesive model all types of information that could be required to maintain any given vehicle. Important goals include providing an interchange and validation structure for any information which may be passed between automatic systems that operate on different software or hardware; providing a generic model for any future information or vehicles which might be included in an electronic system; and allowing repetitive or shared data to be stored only once in any electronic storage system. The technology intent is to make the information independent of the implementation. The CDM is being coordinated with the DOD CALS Working Group and is expected to become a CALS standard.

PLANNED USERS: AFSC, DOD-wide, Industry.

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4. Product Data Control Model (PDCM). Integrated Design Support (IDS) is an R&D program to improve the management of the technical data associated with major Air Force weapon systems. The PDCM is the cornerstone upon which IDS is being built. The PDCM defines all the data entities and their logical inter-relationships needed to provide weapon system engineering support. The PDCM provides the framework for data integration by defining how the enterprise-wide engineering, manufacturing, and operations support products relate from the viewpoint of critical data. The PDCM serves as a bridge between the user and the hardware system, freeing the user from needing to know where or how the particular data one wishes to access are stored. The PDCM is unique to industry and has been acknowledged as one of the first models of its kind that allows one to capture, manage, maintain, and retrieve all the technical data pertaining to a product. This advanced data base management system technology representation has been highly acclaimed by the engineering community for its neutral and logical view, and is actively being studied for implementation within AFALD, NASA, the US Department of Transportation, and various aerospace organizations including Boeing, Martin Marietta, General Dynamics, Rockwell, and Lockheed. It is also playing a significant role in national product data standards development.

PLANNED USERS: ASD, Industry.

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5. Maintenance Diagnostic Aiding System (MDAS). An important function of the Integrated Maintenance Information System (IMIS) will be its ability to aid the maintenance technician in

troubleshooting weapon systems. MDAS is a tool that closely models how equipment behaves under failure and it suggests the best diagnostic or repair options to the technician during troubleshooting. MDAS rank-orders available tests by finding the test which splits the set of suspected faults so that the probability of failure for those faults being tested is approximately equal to the failure probability of those not tested. Probabilities are based on Mean Time to Failure. Test times are then considered so that tests requiring the shortest time are moved to the top of the list of recommended tests, all other things equal.

PLANNED USERS: ASD, Industry.

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6. Authoring and Presentation System (APS). The APS was developed in support of the Integrated Maintenance Information System (IMIS), which will provide technicians with direct access to several maintenance information systems and data bases. A fundamental requirement for IMIS to succeed is the ability to author, find, merge, sort, update, and display graphics and technical information. APS provides the means to generate, store, organize, retrieve, and display electronic technical order information. The APS data base provides the flexibility required to represent the complex interrelated data found in technical orders.

PLANNED USERS: ASD, Industry.

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7. Threat System Relative Lethality Values. The Air Staff and HQ TAC requested statistical support in the development of threat system relative lethality values for a Tactical Air Forces Mission Planning System (TAF MPS). TAF MPS is an automated system that integrates weapons delivery, flight planning, and penetration analysis to select preferred routes through a battlefield. The amount of time available for flight planning is becoming shorter as targets become more mobile. The TAF MPS algorithm is designed to emulate the expert flight planner, with a much shorter response time. Air Force-wide agreed-upon relative lethality values for certain surface-to-air missiles and radar-directed guns as a function of range and altitude do not exist. To identify these values, AFHRL provided consultative support in the development, administration, and analysis of a survey which captured the policies of experienced personnel in rating the relative effectiveness of certain ground-to-air weapon systems. The sample of expert raters was comprised of 44 pilots, navigators, electronic warfare officers, and nonrated personnel from various intelligence and operational organizations. AFHRL performed interrater reliability analysis to determine the degree of interrater agreement. AFHRL then computed descriptive statistics and performed curve fitting analyses to describe relative lethality as a function of range for each altitude/threat system combination. This work provided TAC with the threat system relative lethality data necessary to make the TAF MPS operational.

PLANNED USER: TAC.

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Training Technology

1. Rehosting of Instructional Support System (ISS). ISS is a computer-based tool for development, delivery, and management of training instructions. It operates on the Digital Equipment Corporation (DEC) VAX family of computers, ranging from a MicroVAX II to an 8600, under the Virtual Memory System (VMS) operating system. AFHRL extended ISS as an Ada research activity to port a mainframe-based, hardware-dependent CBT system to a minicomputer and, so, to achieve hardware independence. The Laboratory rehosted ISS to the Zenith 248 (2nd quarter FY 88). The rehosting provided Air Force and DOD users a standardized, low-cost, Government-owned training system. Recent additions to ISS include videodisc, micro-Computer-Managed Instruction (CMI), enhanced system documentation, and stand-alone, exportable CAI and CMI training materials.

PLANNED USERS: SAC, AFIT, AFLC, HSD, ESD, NASA, AFSC, ASD, Army, Navy.

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2. Enhancement of Maintainer's Associate Training Instructional Environment (MATIE II). The Laboratory enhanced a previously developed expert system for maintenance training (MATIE I). The enhancements permitted the further development of an Intelligent Tutoring System (ITS) based upon the maintenance knowledge domain. Two research issues were considered in the development of this ITS. First was an examination of the issues involved in adapting an expert system to the role of an expert module in an ITS. Second was the feasibility of developing a generic ITS that could deal with knowledge domains in other troubleshooting and training areas. The lessons learned from MATIE II are expected to influence the design of several future ITSs.

PLANNED USERS: ATC Technical Training Centers.

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3. Challenger. The goal of this R&D was to develop a prototype Intelligent Tutoring System (ITS) for use in knowledge domains having many mathematical formulae. The Laboratory developed a course in Orbital Dynamics using a prototype tutoring system. The five goals for the Phase 1 effort were: (1) to determine the properties that make a training domain suitable for ITS applications; (2) to develop an intelligent and powerful human-computer interface; (3) to develop a domain model module for the prototype; (4) to develop an effective tutorial module to guide individualized training processes; and (5) to develop a demonstrable ITS prototype in the field of Orbital Dynamics as taught by the United States Air Force Academy (USAFA). The prototype teaches about 25 hours of the curriculum for Block I of Orbital Mechanics. A second-generation system, currently in the planning stage, will add authoring tools to allow ITS development by on-site training development personnel at the Academy.

PLANNED USERS: ATC/XPC, ATC/STS, USAFA.

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4. Microcomputer Intelligence for Technical Training (MITT). Course authoring systems that can be run on microcomputers do not have artificial intelligence capabilities. Techniques that would permit the use of microcomputers to develop tutoring systems with artificial intelligence capabilities are now being explored by AFHRL. During FY 88, the Laboratory used a preliminary version of MITT to develop a shuttle fuel cell tutoring system with artificial-intelligence-based student guidance systems for NASA. The next phase of the MITT program will involve its experimental use at an ATC technical training center.

PLANNED USERS: NASA/JSC; ATC/XPCR.

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5. Advanced Visual Technology System (AVTS). The AVTS project was closed out in FY 88. The AVTS computer image generator (CIG) was designed to provide visual out-the-window and multisensor imagery for the full spectrum of tactical air missions. This includes air-to-surface weapons delivery, low-level flight, acquisition of surface-to-air missiles, evasive maneuvers, and normal flight operations such as takeoff, landing, and aerial refueling. The CIG hardware and software are compatible with different types of display systems and provide high quality, realistic imagery for combat simulations. A data processing technique called "area processing" reduces the amount of computer hardware required and overcomes technical limits of other CIG systems. This technology is being marketed under the trade name Compuscene IV by General Electric. Another product of this AVTS effort is a high-resolution, limited-field-of-view dome visual display originally developed for evaluation of

nap-of-the-earth Army helicopter training effectiveness. The helicopter cockpit has now been replaced by an F-16A to be used in high-speed, low-altitude flight training effectiveness R&D and air-to-air and air-to-ground combat studies. AVTS also provides imagery to an A-10 tactical research simulator and a visual imagery test-bed facility.

PLANNED USER: ASD.

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6. C-130 Visual Requirements. Two studies were conducted concerning field-of-view (FOV) requirements for C-130 weapon system trainers at Little Rock AFB AR. The first study investigated the effects of eliminating peripheral visual information on assault landings using experienced C-130 pilots. The results indicated no adverse effects for this task. The second study investigated the effects of eliminating peripheral visual information on low-level navigation and air drop maneuvers. Pilot eye position was also monitored. The results indicated that pilots could still perform the task without the peripheral windows but that they adopted a different visual behavior pattern in order to do so. A third study involved scene content and investigated the effects of enhanced detail (texture patterns and vertical development) on performance of assault landings. The results indicated enhanced performance in the high scene detail condition.

PLANNED USERS: MAC, ASD.

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7. Job Performance Measurement Systems (JPMS). AFHRL developed job performance measurement instruments in response to a Congressional mandate that the Services establish valid linkages between job performance, enlistment standards, and training results. ATC and AFMPC also have requested that AFHRL work on JPMS. The JPMS incorporates a variety of different types of instruments for measuring job performance; they include hands-on measures, interview techniques, written tests, and rating forms. Under the Joint-Service Job Performance Measurement Project, the performance measurement technology was used to collect accurate information about the performance of first-term airmen. They were selected from career fields representative of the major aptitude areas of the Armed Services Vocational Aptitude Battery. Measurement instruments were developed and data collected for eight Air Force enlisted specialties. The job performance measurement technology and information collected is being assessed for its usefulness in evaluating training programs.

PLANNED USERS: HQ ATC, AFMPC, MAJCOM.

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AUTOVON 240- 2932

8. Guidelines for Range System Development. A series of experiments examined the effects of factors such as real-time and post-mission feedback capabilities on the effectiveness of electronic combat (EC) training systems. The findings from these experiments are: (a) Simple emitter systems cannot support effective countermeasures training or provide real-time feedback; (b) providing accurate post-mission feedback can compensate to a great degree for lack of real-time interaction, but the lack of such interaction may affect the types and timing of countermeasures employed; (c) significant degradation in EC performance occurs over a 4- to 6-month period, with the amount of loss being affected by the level of prior proficiency and the amount of prior training; and (d) significant transfer of training from the flight simulator to the aircraft occurs, as seen in more frequent use of countermeasures on early exercise sorties, These results provide some guidelines for the development of future range systems. In addition, they serve as a training point for an investigation into the integration of the spectrum of training devices to produce an optimal EC training program.

PLANNED USERS: MSD/YI.

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APPENDIX A: CUSTOMER REQUIREMENTS[1]

Rqmt No	Rqmt Title	USER(S)
AFR 30-23	The Air Force Personnel Survey Program	N/A
AFR 33-6	Armed Forces Vocational Testing Program	N/A
AFR 35-2	Occupational Analysis	N/A
AFR 35-8	Air Force Military Personnel Testing System	N/A
RPR 80-01	Basic Job Skills	USAF/LEY/DPP TAC/CV/LG
RPR 80-03	Advanced OJT Management and Delivery System	USAF/DPPE AFMPC/DPMRPQ3
RPR 81-06	Validation of Civilian Employee Selection Procedures	DPCO/MPK
RPR 81-09	Euro-NATO Joint Jet Pilot Training	USAF/DPPTF USAF/XOOTD
RPR 82-08	Officer Data Base/Cohort File	USAF/DPAC
RPR 83-02	Improved Performance Measurement and Prediction	AFMPC/DPCRPQ
RPR 83-24	Improved Selection Procedures for Air Force Physicians	AFMPC/SGEP USAF/DPXA USAF/DPXOP
RPR 84-02	Contingency Task Training Requirements	ATC\XPRR USAFOMC/OMY
RPR 85-01	Expansion of Person-Job-Match Technology	AFMPC/DPCRPQ ATC/XPRR AFRS/RSMC
RPR 85-02	Quantifying Experience in the Cost of Human Capital	AF/DPXA
RPR 8513	Non-Line Officer Projection Model	AF/DPXA AFMPC/SGPY AF/DPXOP

[1]The Requests for Personnel Research (RPRs), Logistics Research Needs (LNs), and Technology Needs (TNs) listed in this Appendix will be replaced with a new system of Manpower, Personnel, and Training Needs (MPTNs). More than 70 new MPTNs have been proposed by AFHRL customers. Many will be in next year's R&T Plan as documented R&D requirements.

Appendix A (Concluded)

RPR 86-03	PJM Methodology	AFMPC/DPMRAS4
RPR 86-05	Nonrated Officer Selection System	ATC/XPRR/RSCX USAFRS/RSMM
LN 79014	Trade-Offs Among Training Manpower, Automatic Test Equipment, and Technical Data	AFALD
LN 81022	Automated Decision Aid for Aircraft Battle Damage Assessment	AFCOLR AFLC/XRXX AFLC/XRS
LN 81155	Bio/Chem Warfare Effects on Aircraft Battle Damage Repair and Maintenance	ABDR AFALD/ERET
LN 84054	Maintenance Air Force Specialty Code Compression	AFALD/XRS
LN 84081	Reliability and Maintainability in CAD	HQ AFSC/PLEL
LN 85003	Remote Fault Isolation LRU Functional Tester	AFLMC/LGM
LN 85018	Flightline Digital Diagnostics and Tech Data	AD/ALP
LN 85023	R&M Requirements Determination	AFALD/ERR
LN 87031	Fully Automated Acft Maintenance Data Collection	HQ SAC/LGME
LN 87077	Determine Skills/Abilities of Future AF Personnel	ESD/DLLT
LN 88071	Advanced Training System for Logistics	USAF/LGXI
TN ASD-0508-82-65	Image Generation for Flight Simulator Visual System	ASD/EN
TN ASD-1705-77-642	Ground Mapping Radar Simulation	ASD/EN
TN ASD-0509-82-63	Flight Simulator Performance Metrics	ASD/EN/YWE
TN ASD-0508-82-66	Visual System Display	ASD/EN

APPENDIX B: FUNDING ($M)

Program Element	Title	Actual FY 88	Actual FY 89	Est FY 90	Est FY 91
61101F	LDIRP	0.9	.4	.4	.4
61102F	Defense Research Sci	1.0	1.0	1.2	1.2
62205F	Trng & Sim Tech	30.9	30.5	29.0	29.0
63106F	Log Sys Tec	8.3	13.7	9.6	13.5
63227F	Adv Sim Tech	7.5	8.2	7.8	9.0
63751F	Trng Sys Tech	0.3	0.5	0	0
	TOTAL	48.9	54.3	48.0	53.1

FUNDS RECEIVED FROM OTHER SOURCES (FY 89)

As of 30 Sep 89 a total of $4.4M was received from other sources to support R&D programs of mutual interest.

Laboratory Operations	FY 88	FY 89	FY 90	FY 91
6.1	.4	.3	.4	.4
6.2	10.4	10.8	11.8	11.9
6.3	1.7	1.6	1.7	1.8
TOTAL	12.5	12.7	13.9	14.1

APPENDIX C: MANPOWER

NUMBER AUTHORIZED FOR FY 89:[2]

OFFICERS 95 ENLISTED 93 CIVILIAN 211 TOTAL: 399

PROFESSIONAL CATEGORY:	Officers	Enlisted	Civilian	Total
Scientific & Engineering (S&E)	88	0	113	201
Technical	5	68	37	110
Other	2	25	61	88
TOTAL	95	93	211	399

ACADEMIC DEGREES:	Bachelors	Masters	PhDs	Total
Psych/Human Factors	25	33	35	93
Computer Sci/Info Sci/Math	23	10	3	36
Engineering	31	8	0	39
Business Adm/Management Sci	10	19	2	31
Education	5	3	4	12
Other	10	11	3	24
TOTAL	104	84	47	235

[2]Authorized personnel decreased by 1 in FY 88, and 4 in FY 89.

APPENDIX D: FACILITIES

An annex to Bldg 578 was completed in January 1990, and contains 2,870 square feet. It will be occupied jointly by the Manpower and Personnel Division and the Training Systems Division. Present facilities are as described below.

	Square Footage	Facility($K)	S&E Equip($K)
Brooks AFB TX--2 Bldgs	75,260	2,483	4,681
Bldg 578: Laboratory HQ Manpower & Personnel Division Information Sciences Division Training Systems Division	73,640		
Bldg 1155--Archives	1,620		
Lackland AFB TX--3 Bldgs	12,706	440	2,500
Bldg 9016-Testing Facility	7,986	(Built 1951)	
Bldg 6321-Paper-and-Pencil Testing	4,720	(Built 1941)	
Wright-Patterson AFB OH--2 Bldg Logistics & Human Factors Division	33,150	548	1,981
Bldg 190-AFHRL LR Personnel	21,600		
Bldg 434-Contract Personnel	11,550		
Williams AFB AZ--9 Bldg Operations Training Division	88,572	11,728	107,616
Bldg 551-Administration & Computers	2,200		
Bldg 552-LMCA Administration Supply Facility	1,647		
Bldg 554-Administration & Computers	2,200		
Bldg 558-ASPT Cockpits	22,485		
Bldg 560-PDT Lab, UNIVAC 1108	9,600		
Bldg 561-Aircrew Training Research Facility	30,660		
Bldg 562-Engineering Support	4,200		
Bldg 567-Administration & Computers	2,200		
Bldg 570-Simulator/Research Facility	13,380		
Luke AFB AZ--2 Bldgs Air-To-Air Combat R&D	3,060		
Bldg 616-Contract Personnel	2,760		
Bldg 617-Contract Personnel	300		
TOTAL: 20 Bldg	222,278 sq ft		